

Metallurgical
& Chemical
Engineering

AUG 1 1916

WASHINGTON

New York, August 1, 1916

McGraw Publishing Co., Inc. Vol. XV, No. 3 25c a copy

"BETHLEHEM-BUILT" CHEMICAL APPARATUS

TANTIRON

THE CHEMICAL RESISTANT METAL
THAT CAN BE BUILT UP

BETHLEHEM FOUNDRY & MACHINE CO.

127 FRONT STREET, SOUTH BETHLEHEM, PA.

NEW YORK OFFICE, ROOM 529 SINGER BLDG.

W. A. HILL, JR., PRESIDENT
J. E. HILL, VICE PRESIDENT AND GENERAL MANAGER
J. E. HILL, SECRETARY
J. E. HILL, TREASURER
J. E. HILL, MANAGER

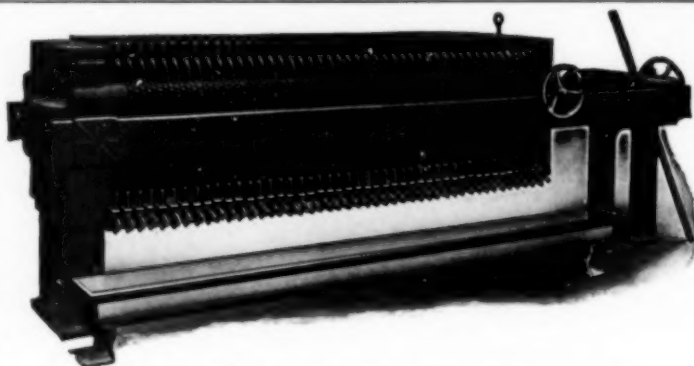
**For Big Production and Low
Operating Cost**

**SHRIVER
FILTER PRESSES**

They increase output and effect marked savings in filter cloth replacements and the recovery of values. Little attendance and less wash water adds to their economy.

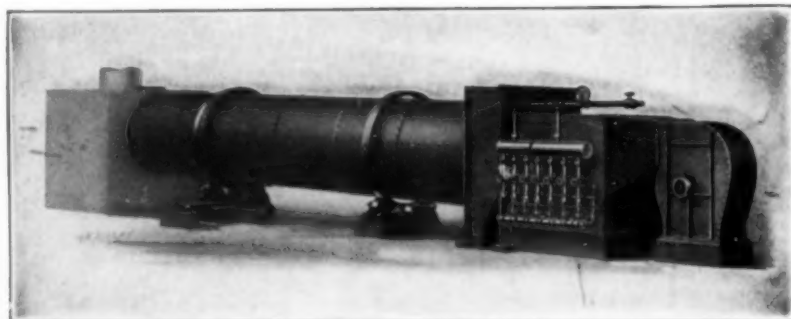
Have wide joint surfaces. Accurate finishing of plates and frames, coupled with an efficient tightening device, prevents leakage.

Presses for all industrial filtration. Small presses for laboratory work.



T. Shriver & Co. 808 Hamilton St.
Harrison, N. J.

STEAM HEATED AIR DRYERS



for Drying Borax, Salts and other Chemicals.

Have equipped largest chemical plants in the world.

Also Direct Heat Dryers for By-Products.

American Process Co.
68 William St., New York

**HEADQUARTERS FOR
50% FERRO-SILICON**

And the Following Carbon-Free Metals and Alloys

Ferro-Titanium, 25% Ti
Chromium, 98-99% Cr
Ferro-Chromium, 60% Cr
Ferro-Vanadium, 40% Va
Ferro-Molybdenum, 80% Mo
Cobalt, 97%

Tungsten, 95%
Ferro-Tungsten, 75%
Manganese, Pure
Manganese-Copper, 30/70%
Manganese-Titanium, 30% Ti

Manganese-Aluminum, 10% Mn
Phosphor-Copper, 15% Phos
Silicon-Copper, 10% Si
Phosphor-Tin, 5% Phos
Nickel-Copper, 50/50%

We have a special alloy for practically every purpose and there are many cases where one of our carbon free metals or alloys is much better and more economical to use than metals containing carbon.

Foundries making Brass, Bronze, German Silver, Nickel, Aluminum or composition castings should investigate our Pure Manganese, and Manganese Alloys.

Write for our Pamphlet 2041

GOLDSCHMIDT THERMIT COMPANY

THE EQUITABLE BLDG., 120 BROADWAY, NEW YORK

329-333 Folsom St.,
San Francisco

7300 So. Chicago Ave.,
Chicago, Ill.

103 Richmond St. W.,
Toronto, Ont.

Metallurgical and Chemical Engineering

A Consolidation of
ELECTROCHEMICAL AND METALLURGICAL INDUSTRY and IRON AND STEEL MAGAZINE

Vol. XV

NEW YORK, AUGUST 1, 1916

No. 3

PUBLISHED SEMI-MONTHLY ON THE FIRST AND FIFTEENTH
OF EACH MONTH BY THE

McGRAW PUBLISHING COMPANY, INC.

JAMES H. McGRAW, President.
A. E. CLIFFORD, Secretary. JOHN T. DEMOTT, Treasurer
239 West 39th St., New York.

TELEPHONE, 4700 BRYANT. CABLE ADDRESS, METCHAM, NEW YORK.
ROCKY MOUNTAIN OFFICE.....421 Boston Bldg., Denver, Col.
PACIFIC COAST OFFICE.....502 Rialto Bldg., San Francisco, Cal.
CHICAGO OFFICE.....Old Colony Building
CLEVELAND OFFICE.....Leader News Building
PHILADELPHIA OFFICE.....Real Estate Trust Building
LONDON OFFICE.....Hastings House, Norfolk St., Strand

E. F. ROEBER, Ph.D., Editor.
H. C. PARMELEE, Western Editor.

J. MALCOLM MUIR, Manager.

Yearly subscription price for United States, Mexico and
United States dependencies, \$3.00; all other countries, \$4.00.

Copyright, 1916, by the McGraw Publishing Company, Inc.

Entered as Second-Class Matter at the Post Office at New York,
N. Y., under the Act of Congress, March 3, 1879.

Contents for August 1, 1916

EDITORIAL:

Why People Should Interest Themselves in Electro-chemistry	109
University and Industry.....	109
The Steel Production Statistics.....	110
Bleeding Kansas	110

READERS' VIEWS AND COMMENTS:

The Dyestuff Tariff. By Edward Hart.....	112
The Ball Mill for Regrinding. By R. B. T. Kiliani.....	112
By-Product Coal Ammonia as a Domestic Nitrate Source. By Lewis A. Riley, 2d.....	112
The Iron and Steel Market.....	113
Coming Meetings and Events.....	114
The Niagara Falls Power Famine.....	115
The Coal-Tar Dye Industry, Past, Present and Future. By Bernhard C. Hesse.....	120
New York Meeting of American Chemical Society.....	124
New York Meeting of American Electrochemical Society.....	124
The Thermal Decomposition of the Aliphatic Hydrocarbon Derivatives of Naphthalene. By Gustav Egloff.....	125
Blast Furnace Irregularities and Their Treatment. II. By J. E. Johnson, Jr.....	127
Flotation Experiments on a Joplin Tailing. By W. A. Whitaker, George Belchic, Roy Neal and H. L. Van Velzer....	131
A School of Chemical Engineering Practice. By William H. Walker	138
Hygroscopic Properties of Sodium, Potassium and Ammonium Nitrates, Potassium Chlorate and Mercury Fulminate. By Guy B. Taylor and W. C. Cope.....	140
Revision of Our Chemical Statistics. By Bernhard C. Hesse	143
An Investigation Dealing with the Occurrence of Alumina Inclusions in Steel. By Albert Sauveur.....	149
Synthesis of Tartaric Acid.....	151
The Flotation of Oxidized Ores. By O. C. Ralston and Glen L. Allen	153

SYNOPSIS OF RECENT CHEMICAL AND METALLURGICAL LITERATURE	155
--	-----

RECENT CHEMICAL AND METALLURGICAL PATENTS.....	157
New Development in Castings of Heat-Resisting and Non-Corrosive Alloy	159
Uranium in High-Speed Steel.....	160
Second National Exposition of Chemical Industries.....	160
PERSONAL	160
OBITUARY	161
INDUSTRIAL NOTES	161
DIGEST OF ELECTROCHEMICAL U. S. PATENTS.....	162

Why People Should Interest Themselves in Electrochemistry

It is remarkable how the conception of the scope of chemistry has recently grown in the general public's mind, after chemistry had been synonymous with drugstores so long to so many people. Everyone is now acquainted with at least one other field of chemical endeavor—dyestuffs—and thus chemistry has made a clear advance of 100 per cent in popular estimation. Among technical men, however, it is electrochemistry that is now attracting greatest attention. Of course, as long as Faraday's law has been taught in schools, those who had to learn it knew of electrochemistry. But for many its scope was restricted to batteries and plating. Naturally electrical engineers knew better, as they had to buy their copper from the electrolytic copper refinery and the generating capacity of an electrolytic refinery is sufficiently impressive to gain the respect of any engineer. No wonder that many a man who had been interested in lighting and traction systems is now attracted by electrochemistry which has no such sources of trouble as a public service commission. Finally the power famine at Niagara—deplorable as it is—has had at least one good result—that attention has been attracted to the nation-wide economic importance of the Niagara electrochemical industries. (Compare the report on page 115 of this issue.) And the doubling in the number of American electric steel refinery furnaces during the last year is but another illustration of the same story.

There are two essential reasons why American engineers should interest themselves in the American electrochemical industries. First, because they are of fundamental economic importance for the whole country. Second, because they are thoroughly American in origin and thus a source of profoundest pride for the nation. We hope that many engineers, and especially electrical engineers, will take advantage of the meeting to be held by the American Electrochemical Society in New York in September, to make themselves acquainted with American electrochemists. There is no more congenial crowd to mix with.

University and Industry

During last winter the New York Section of the American Chemical Society held a series of meetings for the purpose of discussing the various phases of the interrelation between science and industry and promoting a heartier co-operation between the two. All of these meetings, which were fully reported in this paper, were very interesting and very suggestive. But, after all, it is human, all too human, to listen

attentively and approvingly to the preacher's admonition on festival occasion and forget promptly the good intentions in the pressing every-day duties of the morning after.

In this issue we record a real deed. The article by Prof. W. H. Walker on the new chemical engineering course of the new Massachusetts Institute of Technology tells how a splendid idea of most direct co-operation between university and industry is being transformed into reality with a boldness of conception that is unique in the history of chemical education. It is a grand pioneer experiment in education. We heartily wish that it be successful in such overwhelmingly convincing style that in the end it will be remembered but as the pioneer experiment and the forerunner of many others.

The Steel Production Statistics

There have lately appeared the statistics of production in steel ingots, steel castings, and rolled steel in 1915. The figures are studied with particular interest on account of the changed character of demand last year, whereby a large tonnage of steel was rolled for shell making, with unusually heavy discards, and one naturally looks to see whether the statistics indicate the production and consumption of an unusually large tonnage of scrap in the open-hearth furnaces.

One interesting comparison to be made is between the tonnage of basic pig iron and the tonnage of basic open-hearth ingots and castings. The production statistics, with the percentage of pig iron to steel, are given below, also the production of duplex steel for the year for which such statistics were gathered:

	Steel Gross Tons	Pig Iron, Gross Tons	Proportion, Pig to Steel	Duplex Steel, Gross Tons
1896.....	776,256	336,403	43.3	.....
1897.....	1,056,043	556,444	52.7	.....
1898.....	1,569,412	785,444	50.1	.....
1899.....	2,080,426	985,033	47.4	.....
1900.....	2,545,091	1,072,376	42.1	.....
1901.....	3,618,993	1,448,850	40.0	.....
1902.....	4,496,533	2,038,590	545.2	.....
1903.....	4,734,913	2,040,726	43.0	.....
1904.....	5,106,367	2,483,104	48.5	.....
1905.....	7,815,728	4,105,179	52.5	.....
1906.....	9,658,760	5,018,674	52.0	.....
1907.....	10,279,315	5,375,219	52.4	.....
1908.....	7,140,425	5,010,144	57.1	.....
1909.....	13,417,472	8,250,225	61.5	.....
1910.....	15,292,329	9,084,608	59.5	.....
1911.....	14,685,932	8,520,020	58.0	.....
1912.....	19,641,502	11,417,886	58.1	1,438,654
1913.....	20,344,626	12,536,693	61.6	2,210,718
1914.....	16,271,129	9,670,687	59.4	835,690
1915.....	22,308,725	13,093,214	58.7	1,781,491

Thus the largest proportion of scrap used appears to have been in 1901. For a number of years, ability to hold down the proportion of pig iron was due, in part at least, to the diversion of Bessemer scrap from the Bessemer converter to the basic open-hearth furnace. In 1906 there occurred the maximum production of Bessemer steel, its production having decreased since then, while the production of basic open-hearth steel has more than doubled. The percentages given in the above table are not, of course, identical with the average percentage of pig iron charged to the furnaces, but the annual fluctuations are a trustworthy index. The maximum proportions of pig iron fell in 1909 and 1913. The increase in the use of direct metal has made it convenient to use larger proportions of pig iron. In

1915 no less than 73.7 per cent. of all the basic pig iron produced was delivered molten, while 13.3 per cent. of the production was made for sale, and was, therefore, necessarily cast. It is to be observed that the amount of duplex steel produced has really not been large, and this process has, therefore, not thus far decreased to any extent the proportion of scrap used in the basic open-hearth furnaces as a whole. Duplex steel is, of course, reported as part of the total of basic open hearth produced.

The quantity of scrap used in the basic open-hearth furnace in 1915 was only slightly less than in immediately preceding years. There is no doubt that there were larger supplies on account of the liberal cropping practiced on several million tons of steel made in the year. The effect of the extra scrap production appears to have been seen chiefly in an influence operating to prevent the scrap market from advancing as sharply as did the unfinished and finished steel markets.

The figures cited above are suggestive as to the consumption of scrap. As to the production of scrap, there are other figures that can be studied, by making comparison between the production of steel ingots and of finished rolled steel. The statistics of rolled steel are gathered in such form that comparisons from year to year can readily be made. "Rolled steel" includes, in general, material weighed in the form in which it leaves the hot rolls for the last time, but, of course, after shearing. Thus, the statistics refer to sheets and black plates, rather than to sheet bars; to skelp, rather than to welded pipe; and rods, rather than billets or wire. Rolled forging billets and all billets, etc., for export, are included, as otherwise the material would be lost to the statistics. The comparison is as follows:

	Steel Ingots, Gross Tons	Rolled Steel, Gross Tons	Proportion of Rolled Steel
1912.....	30,284,682	23,019,259	76.01
1913.....	30,280,130	23,112,986	76.34
1914.....	22,819,784	17,202,420	75.38
1915.....	31,284,212	23,098,091	73.83

There is scale produced, and in comparing different years there may be slight divergences due to there being larger proportions of light material rolled in some years than in others. Generally speaking, however, there was evidently much larger cropping of ingots and billets in 1915 than in any other year. It is a fact, moreover, that some mills produced ingots late in 1914 for stock, the demand being very light, such steel contributing to the ingot statistics for 1914 but to the finished-steel statistics for 1915; and thus the rolled steel in 1915 may have been less than normal by approximately 3 per cent. of the ingot production.

The fact that the statistics indicate the production of scrap, or billet discards, rather than its consumption, may be explained, in part at least, by the material accumulating at works.

Bleeding Kansas

Kansas is always in the throes of something or other. We hark back to the time when, to all appearances, single-handed and alone, Kansas was fighting the demon rum, with only the encouragement of old Uncle Jehoshaphat Maine, who shouted his hurrahs—between drinks.

Then came Populism and Sockless Jerry Simpson, the while the Kansas farmers ploughed deeper and deeper and bethought themselves of new notions. The trouble with Kansas is that she is never satisfied, and as time rolls on, and as some of us grow old and begin to wish that she would settle down and become conservative and sensible, like other folk, Kansas doesn't settle down. It is a nervous and unbiddable community. There is abundant tradition, all over the world, that if anybody has a new idea he should be snubbed and told to go back to that station in life to which, in the minds of conservative persons, it hath pleased God to call him. Such a station of life, in the minds of the truly conservative, is nearly always in the back row.

But Kansas is not conservative. It has no respect for tradition or established forms or justification by cult. It is a nervous, restless place, and is not to be recommended to elderly gentlemen of a gouty or rheumatic tendency, with fixed habits of mind.

At the Kansas State University at Lawrence, as soon as the late Robert Kennedy Duncan began to display chemistry so that it became attractive to the man on the street, they called him to their chair of industrial chemistry. Then when that man o' dreams conceived the idea of establishing industrial fellowships with the view to applying chemistry to daily life and the affairs of men, they took it up immediately, and it is still going at full tilt. Out of this the Mellon Institute of the Pittsburgh University was born, and in it is indicated one real link between the universities and industry. No one who has the development and spread of chemistry at heart can visit the Mellon Institute and observe their methods of attack in industrial research, without becoming inspired with the belief that that is a real thing. The idea comes from Kansas.

The students of chemistry and metallurgy at Lawrence have just issued the first number of an annual paper which they call *The Kansan Chemallurgist*. It has twenty-four pages, and it is utterly devoid of sporting news. That is another innovation! Who ever heard of a college paper without even a baseball or a football score? There is no mention of the hockey team or the glee club or of the most popular man of the Class of '16. This seems unusual enough to be all wrong—to the conservative mind. And yet that magazine is full of readable stuff. It begins with what might be called an horn solo about Kansas and her industries. We learn that in 1914 the value of products manufactured in that State was \$328,936,964. The two leading industries are slaughtering and meat packing, and flour milling; and we might mention right here that there is a crying need for chemical research in regard to flour that has not yet been accomplished either in Kansas or Minnesota or Buda-Pesth or anywhere else as yet. Then come zinc smelting and refining along with the production of sulphuric acid, cement, brick and tile, glass, leather goods, salt, paint and varnish, pottery, dairy products, and a lot more. The zinc production in 1915 was over \$40,000,000 worth—but that may be high-water mark. The cement industry has developed into the millions in output; there are twenty-three glass works, and, alas! it

grieves us to repeat it: "Kansas is not to be left out of the coke industry and can *boast* of sixty-seven bee-hive ovens in the southeastern part of the State." (The italics are ours.) Let us hope that Kansas will soon cease to boast over bee-hive coke ovens.

There is an article by L. S. Bushnell, who urges young chemical engineers to get into the works rather than into the laboratory to the end that they may learn to produce, and Dr. Charles H. Herty comes along with the advice not to jump into jobs too soon at the expense of adequate preparation. But this is said with such grace and *savoir faire* that it sounds less like advice than like a good thing to know. The university has a department of State Chemical Research under Prof. W. A. Whitaker, and this is conducting investigations in the following subjects: prevention of zinc mineral wastes by means of flotation, salt deposits of the State combined with a potash quest, survey of natural gases, removal of iron and softening of municipal water supplies, disposal of municipal sewage and studies of the yucca plant and of sunflower oil.

We learn also that there is a K. U. Chemical Club which meets Wednesdays in which the following papers have been read by members of the faculty during the current year: standardization of chemicals and drugs; effect of radio-active substances on plant growth; ductless glands; micro-metallography of ores in the Comstock Lode; notes on salicylic acid and its allies; chemistry 3000 years ago, antaphylaxis and antaphylactic reactions, enzymes and enzyme action, electric culture, putting your uncle to work, and preparation and use of hydrogen during the European war. Then, as though resolved to be in the fashion, they have a Society of Chemical Engineers with papers by research students and men of affairs in the industries. We find that the chemical faculty of the University numbers twenty-two and the record of the alumni indicates that they stick to chemistry. Here and there one falls from grace, as in the case of a member of the class of 1892 who is now literary editor of one of the leading magazines published in New York. Six are fellows of the Mellon Institute.

The purpose of these remarks is criticism: criticism of those young men of Kansas for their own good. We have mentioned Sockless Jerry Simpson with what was designed for scorn, and we do not approve of the name "Chemallurgist." We think the English language has enough burdens to bear without inventing new ones for it. But when we have said this we can find no more fuel for our critical fire. It seems as if those fellows were live wires. We shall put their magazines away in our files and expect to read their names again. Somebody out there seems to know how to teach and to inspire young men, and the material appears to be of good quality.

Of course, Kansas will continue to bleed. She must bleed in order, to quote Scripture, "that the prophecy may be fulfilled"; that we may continue to use the expression to which our tongues have accustomed themselves. But it doesn't seem to do Kansas any harm. She appears to be taking care of herself. We should like to see some other States do a little similar bleeding.

Readers' Views and Comments

The Dyestuff Tariff

To the Editor of Metallurgical & Chemical Engineering

SIR:—In reading over the copy of the "Dye Stuff Tariff Before Congress," reported on page 65 of the July 15 issue, I notice that several articles such as hydroquinone, pyrocatechin and phenolphthalein and possibly some others, have been omitted in the proposed bill, and I have wondered whether this omission was intentional or accidental. The necessity for protecting these articles is not by any means imaginary, since some of them have been made the subject of dumping by the producers abroad, much to the detriment of our manufacturers. I regard the injection into tariff provisions of a really efficient anti-dumping clause as of even more importance to our industries than a prohibitive tariff rate.

That very unfair practices have been indulged in by importers is known to all of us in the profession, and the law makers need careful instruction if this is to be really avoided in the future.

When I was running for Congress two years ago in the 26th district, I had a letter from the president of one of our largest chemical companies wishing me success. For said he, "We have not a single person in the House of Representatives to whom we can go and talk intelligently with the expectation of being understood."

Easton, Pa.

EDWARD HART.

The Ball Mill for Regrinding

To the Editor of Metallurgical & Chemical Engineering

Sir:—The writer was very much interested in reading the article on "Concentration and Flotation of Lead Ores in Southeastern Missouri," in your issue of July 15, 1916, since he has just returned from an extensive trip through this district.

Under the heading of "Crushing and Grinding" a statement is made to the effect that "the first introduction of the modern ball mill for regrinding is being made at the Rivermines Mill of the St. Joseph Co., where an 8-ft. dia. Marcy mill operated by a 200-hp. motor is being placed." This statement is not quite correct, since a 6-ft. Hardinge ball mill has been in operation at the plant of the Desloge Company since the early part of April, 1916, for the regrinding of their jig middlings. Two further Hardinge ball mills are also being installed in this district at the present time, one, an 8-ft. dia. machine at the plant of the Federal Lead Co. at Flat River, driven by a 125-hp. motor and the other a 6-ft. dia. machine in the Bonne Terre plant of the St. Joseph Lead Co. These machines are all intended to regrind minus 9 mm. and plus 2 mm. jig middlings for table concentration in place of the rolls which have previously been employed for this work.

The Hardinge ball mill at the plant of the Desloge Co. was the first introduction of a modern ball mill of either the conical or cylindrical type in this district and antedated the introduction of the cylindrical mill at the Rivermines mill by some three months.

R. B. T. KILIANI.

Hardinge Conical Mill Co.,
New York City.

By-Product Coal Ammonia as a Domestic Nitrate Source

To the Editor of Metallurgical & Chemical Engineering

SIR:—The present unusual interest which is being given to the development of those industries and proc-

esses which are necessary for the production of war munitions and as a means for preparedness has a tendency to cause certain assumptions to become fixed in the public mind as basic facts and which form the starting point for all discussions. This tendency may cause us at this time to take action which will restrict the development of certain of our natural resources rather than assist them. For instance, certain of our scientific authorities are at this moment making the radical assumption that the basis of an independent source of nitric acid lies solely and only in the development of cheap water power.

The object of this short discussion is to call attention primarily to the fact that we have at hand the potential elements of the cheapest electric power and an almost unlimited supply of raw material for nitric acid, and that these elements do not depend upon or concern themselves in the slightest way with the development of water power.

It might be well to consider for a moment the possible sources of the nitric acid supply which our military authorities consider to be the essential element in the manufacture of explosives in case the seas were not open to our commerce.

Outside of the well-known Chile nitrate beds on which we depend at present, there exists three possible sources of nitric acid supply:

First—The electric arc oxidation of atmospheric nitrogen to the nitric oxides and the conversion of these to nitric acid direct. (The Birkeland Eyde and Pauling processes.)

Second—The hydration of atmospheric nitrogen to ammonia in the electric furnace or catalytic process and the subsequent oxidation of the ammonia to nitric acid (The Haber process and more indirectly the cyanamid process).

Third—The oxidation of ammonia formed directly in the coking or gasification of our bituminous fuels to nitric acid by the catalytic process. (The Ostwald process is also the final step under Class 2.)

All these three sources are being utilized by the warring powers in Europe at the present time on a large commercial scale.

The first two processes require a very large input of electric energy and the second requires in addition large quantities of raw material in the form of lime and coke.

The first two processes are receiving at the present moment a vast amount of publicity and it is generally acknowledged that their successful operation depends primarily on the ability to obtain extremely cheap electric power.

It is further being assumed that this cheap electric power can only be obtained from water-power development.

Some further consideration should be given to the third process which has been almost totally neglected in recent discussions. It is a well known fact that bituminous fuels contain an important percentage of organic combined nitrogen in such form that by treatment in processes such as the by-product coke oven the coal gas retort and lastly in the by-product gas producer, considerable quantities of ammonia are generated and recovered as a by-product.

It is not so generally understood, however, that in the by-product gas producer as developed in Europe during the last twenty-odd years approximately 70 per

cent of the available ammonia in the bituminous fuels can be recovered and made available, and that this percentage of ammonia is approximately four times the amount per ton of coal which can be recovered in a modern by-product coke plant or coal-gas plant. These by-product gas producers recover also a considerable amount of tar and generate besides these by-products a fuel gas which is entirely suitable as fuel for industrial furnaces, for the usual steam turbine plant or gas engines.

A complete power-producing unit of this character is, therefore, capable of solving two of our difficulties at the same time. It will furnish cheap electric power to be used in other processes and it will, also, as a by-product, produce a large quantity of ammonia suitable for fertilizer in peace times and convertible to nitric acid in case of war.

Some doubt has been thrown on the commercial practicability of oxidizing coal ammonia to nitric acid by some of our technical experts. There is no question, however, that this problem has been completely solved on a commercial scale in Germany. The writer has the records of a commercial plant which operated steadily for five years before the start of the war using coke-oven ammonia to produce nitric acid.

By the combination, therefore, of a power plant using by-product producers with ammonia oxidation apparatus we have a unit which produces ammonia and the resulting nitric acid together with a very large output of electric energy which may be applied to other industrial uses or to the production of further nitric acid by either of the other processes referred to above. The raw material which is required to produce this ammonia and electric power is bituminous fuel.

It is possible to demonstrate by using the most modern designs which have been adapted to American conditions that power can be generated in a plant of, say, 100,000 hp. capacity at a cost less than \$5 per horsepower per year, including all fixed charges. This is cheaper power than Niagara, of which we hear so much present talk. It has certain unmistakable advantages over Niagara power. Firstly, it is cheaper in first cost of plant. Secondly, it produces large quantities of a nitrate base and fertilizer as a by-product and the main product, either cheap electric current, or a good fuel gas is available for other electrochemical work or more nitric acid production. The obvious economy of this producer gas process lies in the fact that ammonia and tar worth approximately \$3 is recovered in the gasification of one ton of fuel. The cost of this ammonia recovery is less than \$1 per ton of fuel.

As an evidence that these remarks are neither visionary nor premature, attention is called to the fact that the German Government installed a plant of this character two years before the war started, at its central station at Heinitz, Germany. At the time the war started there were approximately eight plants of this kind operating in Germany. England has about forty such. The combined coal capacity of the plants of this type in operation abroad is approximately 2,000,000 tons per year. Japan has also four large plants and is about to build another large one. One of these is owned by the Japanese Government.

While the process is by no means experimental, nevertheless considerable development work has been done in a full-sized plant in this country during the past two years in adapting the foreign designs to American fuels and conditions. This work has demonstrated clearly the large possibilities of the process under our conditions when employing the latest mod-

ern designs. Mine refuse also has been regularly used in this plant; a material which had previously been considered utterly worthless.

The possibilities which lie in locating a by-product producer power plant adjacent to the bituminous coal mines and using the extremely cheap American fuels as a source of cheap electric power have not been appreciated in the recent discussions concerning the development of our water powers and other natural resources. In this respect the by-product producer industry is suffering under the same neglect which overtook the by-product coke industry after the first few failures of the foreign designs which were brought bodily to this country and installed and operated without carefully considering our local conditions and fuel characteristics. For many years the by-product coke industry in Europe enjoyed a rapid development while the industry here remained practically dead. At the present time, however, there is no question of the success of coke production with the recovery of by-products.

The problem of producing fuel gas for power generation with the recovery of tar and ammonia is one which promises to develop with equal rapidity during the next few years. In the opinion of those who have studied its development in Europe it presents no inherent difficulties and the recent demonstrations and development work to adapt same to American conditions have shown that its introduction here on a commercial scale is both practical and profitable.

It is particularly important at this crisis in our national affairs that we give full consideration to all possible means of conserving our natural resources in regard to electric power as well as of ammonia and nitric acid raw materials. It should not be forgotten, therefore, that we are destroying yearly the available ammonia in nearly four hundred million tons of bituminous coal. We recover at present only about 1½ per cent of the available ammonia which might be extracted from such coal by fully developed and well-known methods. In recovering the ammonia from these fuels by the producer gas process one merely converts the fuel value of the coal into fuel gas. This gas can be used in most industrial operations more readily than by burning the coal direct. If only 5 per cent of the available ammonia contained in these fuels which we are destroying were recovered we would have an ammonia base for nitric acid or fertilizer production which would make us entirely independent in peace or war, of foreign importations.

LEWIS A. RILEY, 2D.

New York City.

The Iron and Steel Market

No increase in activity has occurred in the steel market. Buying by the domestic trade continues very light, while export demand continues at about the proportions obtaining in two or three months past. The dullness in the domestic market is attributable solely to the season of the year, when new commitments are never undertaken in a large way. The pressure for deliveries of material already bought is substantially as heavy as ever.

As noted in the report of a fortnight ago, the dullness in the steel market serves to show the fundamental strength of the situation, as there is no wavering in the matter of prices and no seller is making a special effort to effect sales.

So strong does the market appear that predictions are occasionally made as to a fresh buying movement in the fall, and one of no mean proportions. Two months ago

such a prediction would have been considered visionary by practically all observers.

One element is present to induce buyers more readily to take hold, that being the large export demand. It was this influence that caused the first really aggressive campaign of buying in the domestic market a year ago. For months domestic buyers had been strongly of the opinion that during the war no really strong and active steel market could be developed. Then, in June and July, they modified their views to such an extent as to admit the possibility that export demand might perhaps become so great as to make steel scarce. It was the fear of such a development that caused the first really important buying in the domestic market, and it was months before it was realized that the export movement was not especially heavy, and that it was domestic business that was filling the mills.

Now, however, the export business has become much larger from a tonnage standpoint. Following is a summary of exports of the so-called "tonnage" products, those that are returned by weight in the government statistics, including scrap, pig iron, unfinished steel, finished rolled steel, pipe, wire products, etc.:

	Gross Tons
Monthly average, first half 1915.....	216,000
Monthly average, second half 1915.....	377,000
Monthly average, four months 1916.....	387,000
May, 1916	540,549

Export orders placed during the past two or three months suggest that exports during the remainder of the year are likely to be larger rather than smaller than those of May.

Shipments at Higher Prices

The advances in steel prices practically ended in March, and as the mills had been unusually reserved in the matter of booking open contracts the average invoice price of shipments has been approaching the current market level more rapidly than is usually the case in these upward market movements. As a check to such a generalization it may be cited that the estimated shipments of the United States Steel Corporation during the first six months of this year are substantially equal to the unfilled obligations the corporation reported for the close of business in December.

A further evidence that really high priced steel, steel averaging not far from current market prices, with, of course, various exceptions in special cases, is found in the remarkably high earnings reported by the Steel Corporation for the months of May and June. The monthly earnings have been as follows:

January	\$18,794,912	April	\$25,423,673
February	19,196,396	May	27,554,899
March	22,722,316	June	28,147,476
Quarter	\$60,713,624	Quarter	\$81,126,048

An interesting computation, not accurate, of course, but still quite illuminating, can be made. The corporation's daily shipments are assumed, from various data, to have increased from 47,000 tons daily in January to 51,000 tons daily in June. There were wage advances Feb. 1 and May 1, and the January, May and June earnings are corrected to what would presumably have been earned had the wage rates prevailing from Feb. 1 to May 1 been paid in those months. Finally, deductions are made for estimated profits in ore transportation in April, May and June. With these allowances the apparent profits per ton of steel shipped are computed roughly as follows: January, \$14.30; February, \$16; March, \$17.25; April, \$20.25; May, \$21.15; June, \$21.15. The computation is subject to considerable error, but it is sufficiently close to indicate that the rapid increase in earnings, due to higher realized prices, ended about May 1. Increases in earnings due to higher realized prices will come much more slowly in future. Incidentally, it

may be remarked that the Steel Corporation's earnings increased by more than \$20,000,000 from the first quarter to the second quarter, the third quarter is unlikely to show any material increase over the second. Shipments will be less, on account of hot weather, and the June rate of earnings is quite unlikely to be maintained.

Base prices of finished steel products, for shipment at mill convenience, are strictly maintained, and the market is very strong indeed in that respect. Premiums for early shipment, which decreased materially during the second quarter of the year, have shown, if anything, a slight increasing tendency in the past two or three weeks, plates being easily the leader in this respect, prompt deliveries being a shade higher than 30 days ago. Steel, as steel, is still scarce, and Bessemer is less plentiful, relative to open-hearth, than a month or six weeks ago, there having been fairly large buying by foreign and domestic consumers who set out to obtain open-hearth but contented themselves with Bessemer in order to secure desired deliveries.

Steel production has been materially curtailed by the hot weather of July. Labor is more independent than usual and yields to the influence of hot weather.

New construction work is proceeding very slowly, and the increases in steel making capacity month by month are relatively small, quite below the expectations.

Pig Iron

The pig iron market continues to drag along an uneventful course. There is neither buying pressure nor selling pressure. The buyers represent that they are well covered and have no occasion to take an interest in the market, nor do they admit that there is any prospect of their requirements increasing. The furnaces appear to be well sold up, and are quite content with the rate at which pig iron is being taken out against contract. Thus there appears to be an even balance, except for two possible circumstances. In the case of the foundries there have been labor troubles galore, and in some cases at least these have resulted in pig iron being piled in foundry yards. Should the melt continue to be restricted on account of labor scarcity and strikes the foundries might take somewhat smaller shipments in future, while, on the other hand, if they were able to increase their melt they might buy additional iron. The other circumstance that may affect the pig iron market is the action of the large steel interests. They are endeavoring to bring in new steel-making capacity, and their stocks of pig iron have become very small. There is a possibility of some of the large steel makers buying pig iron in the market, and the balance is now so delicate that in such an event price advances would probably be forced, and after such a long period of practically stationary prices the effect upon regular buyers, who are now indifferent, would probably be electrical.

Coming Meetings and Events

American Institute of Metals and American Foundrymen's Association, Foundrymen's Convention, Cleveland, Sept. 11-16.

American Institute of Mining Engineers, Arizona, Sept. 18-23.

Mining and Metallurgical Society of America, New York Section, New York, Sept. 21.

Second National Exposition of Chemical Industries, New York, Sept. 25-30.

American Chemical Society, New York, Sept. 25-30.

American Electrochemical Society, New York, Sept. 28-30.

Technical Section, American Paper and Pulp Association, New York, Sept. 25-30.

The Niagara Falls Power Famine

Meeting of the Committee on Foreign Affairs of House of Representatives and the Niagara Falls Board of Trade

At a luncheon-meeting given by the Niagara Falls Board of Trade to the members of the Committee on Foreign Relations of the House of Representatives at the Prospect House, Niagara Falls, N. Y., on July 13, 1916, the electrochemists presented their side of the power question in such a concise and convincing manner that we feel it a duty and pleasure to publish all the speeches in full.

Hon. CYRUS CLINE presided.

The members of the Committee on Foreign Affairs were welcomed to Niagara Falls in a gracious little speech by Mr. W. ACHESON SMITH, general manager of the Acheson Graphite Company, as one of the five men who now rule Niagara Falls under the city-manager form of municipal administration.

After luncheon Chairman Cline opened the formal meeting.

Mr. F. A. J. FITZGERALD, president of the American Electrochemical Society, was the first speaker:

It is very appropriate that something should be said to-day about the chemical industries of Niagara Falls, for it is almost exactly 21 years since the current from the Niagara Falls Power Company's generators was turned into the aluminum pots of the Pittsburgh Reduction Company and the greatest electrochemical center in the world was born.

The aluminum process, the first of these great Niagara Falls industries, was invented by the late Charles M. Hall and a few months later in the same year that master-inventor, Edward G. Acheson, started to manufacture carborundum. This, with the assistance a few years later of Jacobs' alundum, has revolutionized the abrasive industry all over the world. Shortly after the manufacture of carborundum started we had the first plant making Willson's calcium carbide. Then followed the great plants making caustic soda and bleaching lime by the process of Hamilton Young Castner and another great factory using the same inventor's method for the production of sodium. During these years Rossi was carrying on at Niagara Falls his experiments on ferrotitanium which have resulted in one of our most important industries. We have here also thousands of horsepower devoted to the manufacture of other ferroalloys such as ferrosilicon, so absolutely necessary to the production of steel. But it would take altogether too long to attempt mentioning all the developments of American inventive genius and enterprise which have flourished on the fertile soil created by Niagara power.

There is, however, another side of the subject which is by no means so cheerful, for the brilliant prospects of a few years ago are becoming dim. Since the great war broke out public attention has been strongly directed to the manufacture of nitric acid from the air; but, outside of technical circles, very few people know of the pioneer work done on this problem by Bradley and Lovejoy at Niagara Falls. Their work soon showed that for the successful working of the process enormous quantities of cheap power would be required and consequently the enterprise was never brought to a commercial basis. Yet to-day there are less efficient processes than that of Bradley and Lovejoy working in countries where sufficiently large quantities of power can be obtained.

There is a widespread but erroneous belief that the development of the electrochemical industry will spoil the scenic beauty of the Niagara Falls and this undoubtedly seriously threatens the existence of the industry. Again in this relation we hear much about the exploitation of natural resources by private interests and the consequent injury to the public. But as so often happens in cases like this the real interest of the public has not been considered. For this oversight neither the public nor our legislators are to blame simply because those who know better have never taken the trouble to explain to others the relation of Niagara Falls industries to the public at large and how every citizen of the United States is vitally interested in them.

Now, at the eleventh hour, when these industries are facing a serious crisis those who realize what this means

are anxious to devote all their energies to giving the widest publicity to what they know.

Mr. FRANK J. TONE, works manager of the Carborundum Company, spoke of the Niagara electric furnace companies as follows:

In speaking of the electric furnace industries here, I wish to mention very briefly how these industries have originated, what products they make and more especially what an essential part these products have become in the industrial life of this country. Our electric furnace industries comprise aluminum, calcium carbide, carborundum and the artificial abrasives, ferroalloys and artificial graphite. In the first instance these products have all been made possible by Niagara power. Most of them were discovered a few years previous to the development of power here, and in 1895 some of them were struggling along with steam power, some were laboratory processes and some were still laboratory curiosities. When electric power became available here in large quantity and at a reasonable price it became possible to develop these new metallurgical products on a commercial scale and now they have become so indispensable that a failure in the supply would be a calamity to some of the greatest industries of the country.

Take for example the making of steel, the greatest of all American industries. In 1915 we produced 28,000,000 tons of steel in this country and in two-thirds of this there was required ferrosilicon, an absolutely essential element in producing sound castings and sound ingots. At the beginning of the war all the ferrosilicon used in this country was made by Niagara power in plants located both here and on the Canadian side. The Dominion Government at once placed an embargo on the exportation of ferrosilicon to the United States, all of this alloy being required for use in Canada and in Great Britain. This threw the burden of supplying the American market entirely upon the ferrosilicon works at Niagara Falls and caused an acute shortage which still continues. A cessation in the supply of ferrosilicon would shut down every steel mill in America.

Silicon metal is another Niagara product of importance to the steel industry. It is used in making transformer steel for electrical apparatus and greatly reduces the electrical losses. It is saving millions of dollars annually wherever electrical energy is being transformed. It is also used for the generation of hydrogen for dirigible balloons and balloons for military purposes. Every army in Europe to-day is equipped with apparatus for the use of silicon in connection with their observation balloons.

Perhaps the most striking illustration, however, of the dependence of industry on Niagara power is that of high speed steel. This requires in its manufacture the alloys ferrochromium, ferrovanadium and ferrotungsten. All these are products of Niagara power. Before the invention of high speed steel when we used ordinary carbon steel, a metal cutting speed of 15 ft. per minute was commonly employed. Contrast this if you will with what may be seen in any machine shop where a tool of high speed steel running at a red heat at a speed of 40 or 50 ft. per minute is taking off chips 1½ in. wide and ¼ in. thick. High speed steel has tripled the capacity of every machine shop in the world and the efficiency of every workman. It has cut to one-third the capital investment in plant required to accomplish a given volume of work. This is due to ferrochromium, a product of Niagara power.

Ferrochromium is also the hardening agent used in making armor plate and armor piercing projectiles. Without it we would be unable to equip a single battleship with protective armor or serve a single coast defence gun with modern projectiles.

The battleship Pennsylvania, our latest dreadnought, has 10,000 tons of armor. This required in its manufacture 300 tons of ferrochromium. That is to say, 12 carloads of a Niagara product has gone into the battleship Pennsylvania, and if the United States is going to embark on a broader naval policy one might ask, "Where is the ferrochromium coming from?" It certainly is not coming from Niagara Falls unless there is a change in the power situation here. I might answer that if things continue as they are we will go to Canada or Norway for ferrochromium for our armor plate.

An armor piercing projectile is an interesting product. Fired at a distance of 8 miles to pierce 12-in. armor plate, it must have an energy of 30,000 full tons or twice the energy of a modern express train running 40 miles per hour. It pierces the plate and passes completely through it without suffering deformation. This is because the point is made of chrome steel produced from ferrochromium, a Niagara Falls product.

Another product that Niagara Falls power has brought

into every day use is a metal aluminium. It was the pioneer industry to use Niagara power and its beginnings were small. Last year the production was 80,000,000 lb. It is used in electrical transmission conductors, cooking utensils and various metallurgical purposes, but perhaps the most important use is as a structural material in aeroplanes and automobiles. The shortage to-day is very acute and is regarded by automobile engineers as little less than a calamity.

Calcium carbide is also a product of great importance to industry. We know it best in the acetylene lighting of towns, isolated buildings, miners' lamps and harbor buoys. However, by far its most important use is in the oxy-acetylene flame for the welding and cutting of metals. In the steel foundry we see an oxy-acetylene flame cutting sprues of castings and replacing 12 men working with the old methods. Several years ago, when the Quebec Bridge collapsed, engineers said that it would require as much labor to remove the wreck as it would to put up a new bridge, but it was found that these huge twisted girders could be cut up very successfully by the use of the oxy-acetylene flame. Without the oxy-acetylene flame the battleship Maine could never have been chopped up and removed from Havana Harbor. When the steamer Eastland turned turtle in the Chicago River it was the oxy-acetylene flame that made it possible to quickly cut a hole in the hull and rescue scores of passengers. It is Niagara Falls power that has given this wonderful tool to industry.

Other important Niagara products are carborundum and alundum, artificial abrasive or grinding materials. They are fundamental elements in the metal-working industries and Niagara Falls has always been the sole seat of the industry in America. At the beginning of the war the supply of the natural abrasives, Turkish and Grecian emery, was entirely cut off and it became necessary for the artificial abrasive manufacturers in the Niagara district to supply the entire demand. This has resulted in an acute scarcity of the product. The shutting off of the supply would have crippled the great metal working industries of the country such as automobiles, locomotives, agricultural implements, electrical machinery, paper-making machinery, flour milling machinery, firearms and all manufactures of steel, iron and brass. For example, take the automobile industry. The perfection of the modern automobile and the interchangeability of its parts have been largely brought about by the development of the modern grinding wheel. Practically every part of the automobile is ground at some stage of its manufacture; crank shafts are roughed and finished with grinding wheels, likewise cam shafts, pistons, cylinders, ball bearings, etc. It is no exaggeration to say that if the automobile manufacturer was now deprived of artificial abrasives and compelled to go back to the grindstone, and at the same time we took away the other products of Niagara power, aluminum, oxy-acetylene welding and high-speed steel, a works that now produce 500 cars per day would be reduced to an output of 100 cars per day with the same plant and same workmen and the cost would be correspondingly increased. In fact, there would be no automobile industry on its present existing lines.

A word in regard to the power situation in the abrasive industry because it is typical of many Niagara industries. The Carborundum Company has a plant with an electrical capacity and a furnace capacity of over 20,000 hp., and all the power it can get to-day is 10,000 hp. for a continuous 24 hr. load. It has therefore constructed a works in France of 7000 hp. capacity and is bringing all the product over here for distribution to the American market. As the situation has become more critical during the past few months it has decided to build a plant across the river in Canada using Niagara power, and this plant is now under construction. Practically the entire output will be brought over for use in the American market.

We are striving to-day to make America industrially self-contained, but while the demand for the products of Niagara power by the great and basic industries of the country is increasing at a very rapid rate, our ability to supply these products is by no means keeping pace with the demand. It does not even remain stationary. Our ability to meet the demand for these essential products of the electric furnace is actually decreasing month by month.

Mr. A. H. HOOKER, technical director of the Hooker Electrochemical Company, in speaking of the Niagara electrolytic industries, addressed the committee as follows:

During your trip in the automobiles on Buffalo Avenue as you turned and came back, the plants farthest up were the Oldbury Electrochemical Company and the Phosphorus Compounds Company, where they are making chlorates

and phosphorus and its compounds, products which are vital to the match industry of the country. Phosphorus also finds an important and irreplaceable use in the metal industry as a deoxidizer and hardener in many non-ferrous alloys, chiefly in the phosphorizing of copper for the manufacture of phosphor bronze used on battleships and for certain bearings on machines. The use of chlorate in gunpowder is also known to all. Next to these plants in line is our own plant, the Hooker Electrochemical Company, to which we have made large additions in the last year; directly across the road is the Niagara Alkali Company. Both plants make caustic soda and chlorine products.

I shall tell you something about some of the uses of these products. For instance, in the paper industry chlorine in the form of "bleaching powder" is used; for every 100 tons of book paper there are 20 tons of bleaching powder used. So you see what a vital product it is in this industry. Then it is an all-important disinfectant. The water in a thousand cities of this country is by the use of "chloride of lime" or calcium hypochlorite, or free chlorine, sterilized to a point where we need no longer have typhoid epidemics. Our own city, Niagara Falls, is a wonderful example of such use. Not long ago Niagara Falls was a typhoid fever plague spot—nothing less—caused by our use of water polluted by the sewage from Buffalo and other cities; but now that is all changed and we have not had a single case of typhoid; no, I won't say a single case, but practically that—since this same chlorine treatment of our water was started. I leave it to your imaginations to see whether or not other cities will not follow our example and use this product for the same purpose until it has become invaluable for the purification of our water supplies. Our own army is now using the same chlorine treatment to avoid the dangers from typhoid which beset our soldiers during the Spanish-American war. In Europe the best preventive of blood poisoning and infection from dirty wounds is reported to be a mixture prepared from "chloride of lime" or "bleaching powder." Without this same "bleaching powder" our cotton dresses and sheeting would no longer be white; our shirts and collars from the laundry would be a dirty yellow; and, what is worse, a serious menace to health would result through lack of disinfection. Also, white cotton batting, bleached shellac, chloroform for surgical operations, even the disinfection of our garbage and sinks, call for chlorine in the form of "bleach." This same chlorine is used for the production of carbon tetrachloride, which in the form of "pyrene" has become a household necessity as a fire extinguisher.

Chlorine is used to-day not only in the form of "chloride of lime" for bleaching, for the bleaching of paper and textiles, but it also enters into a wide number of products that we do not ordinarily think of. For instance, a large addition recently made to our plant has been for the chlorination of benzol. Chlorbenzol is one of the coal-tar intermediates which this country has never before produced. Prior to one year ago I believe there had not been 200 lb. of chlorbenzol made in this country—I think we made something like this amount at that time—but to-day there is being made many thousand times that amount right straight along.

By passing chlorine gas into benzol or toluol there is formed hydrochloric acid and chlorbenzol or chlortoluol and the latter products can then be used to form picric acid, benzoic and trinitrotoluol, etc.; it is equally desirable for the production of sulphur black used for a dye, for instance of your socks, and for the production of carmine reds that are used on our automobiles and cars and agricultural implements, and hundreds of other directions in the manufacture of dyes. So for explosives in time of war or for dyestuffs in time of peace, we are getting ready to be of service.

These industries which we have developed and those which we are starting now, for which the country feels such an urgent need, we want to keep in this country, and want to keep them here permanently. I do not see how we are going to continue with the power situation as it stands to-day. We have taken the risk of putting a large sum of money into these new industries, and we have got to grow, or else, as with everything else, we shall reach a point of stagnation. That growth will require more power, not less, as times goes on, because we have got to have additional products; and so it is all down the line, the same proposition occurring all through the electrochemical industries.

Take caustic soda, so vital to the soap industry, so vital to the manufacture of artificial silk, the refining of oils and the mercerizing of cotton, the manufacture of dyes, explosives, cleaning of metals, etc., I believe you all know what household lye is, what caustic soda is, and what a vital part it plays in our many industries and how important it is

to our whole nation. The two plants named above and the pioneer company, The Castner Electrolytic Alkali Company, which make caustic as well as chlorine compounds, are absolutely dependent upon Niagara Falls power, and turn out a great deal of the caustic soda produced in this country.

When you got down a little farther on your trip you came to the plant of the Niagara Electro Chemical Company, making metallic sodium, using this same caustic soda produced at Niagara Falls. This metallic sodium is converted into cyanide, and upon this product depends your gold and silver mining industries, the plating industry, etc. The country being cut off from the supplies of German sodium cyanide, it looked for a time as if our mining industries would be seriously affected, but with enlargements and increases in our own production we have been almost able to hold our end and keep up with the necessities. A great deal of cyanide is used in killing the enemies of citrus trees, and California citrus fruit crops are dependent somewhat upon cyanide made from Niagara power.

From sodium is made sodium peroxide from which again is made hydrogen peroxide, which is used for bleaching and which also is used in the household. From sodium peroxide is made a material which is used as a source of purifying air in submarines, in life-saving work in mines, hospitals, etc. I speak only of these as a few of the different electrochemical products we are making here at Niagara Falls, and their relation—their vital relation—to the industries of the country.

I well remember a little situation that came up to me in December as showing this condition. A cotton batting mill had neglected to make contract for bleaching powder. They possibly thought it would come down in price, or else neglected it, thinking it not a very important item in dollars and cents, as the price of the product was cheap—a little over a cent a pound. However, they had no contract and came to us in December and wanted to know if we could not supply them with "chloride of lime" to keep them going. I said that I did not know, but would take the matter up with our New York sales office. I telephoned to our New York office, but our company could not supply them, but they did make some arrangement whereby they were able to keep this plant running. The situation was simply this, that the whole country was absolutely swept clear of these chlorine products and they could not be got for love nor money.

I might cite another instance: One of our largest stockholders was using a small amount of bleaching powder. He wanted to buy some small amount of bleaching powder from us, but had no contract and our supply was exhausted. We tried to get some bleaching powder for him and we had to pay \$250 a ton because of the shortage of these products, although we were selling the bulk of our supply for perhaps \$25 per ton.

This simply goes to show the effect of the shortage and the necessity for these products that are made in Niagara Falls, the center of the chlorine industry of the world, and it also shows how vital these products are to the full, economic life of the country. Still it seems like a little thing which you hardly ever think of. So when we have started plants here, if we cannot get the water power to develop them to that stage which is necessary to keep up with the normal demands of the country, or to meet such special contingencies as when the country was shut off from foreign supply by the war, it simply finds every one of these industries in a position where it has to look for another source of power. As Mr. Tone has said, we will have to develop a plant in France or Canada or elsewhere. We have got to grow. We cannot stand still. We have got to have more electrical power, or else we simply lose what we have had in America—the greatest center of the electrochemical industry in the world; and this is a great deal more of an asset to the country than the dye industry has been to Germany. Simply for lack of power we are letting our industries scatter, here and there, over to Canada and elsewhere, instead of keeping them for the benefit of our own country. It certainly seems that we should keep our industries right here, and that some means should be devised to utilize the maximum power from the Falls.

We cannot stand still; we have got to grow.

Mr. I. R. EDMANDS, consulting engineer of the Union Carbide Company, was the next speaker and made a positive suggestion as to how to go about in order to get a new international agreement:

I believe you will all agree that the power that has been developed at Niagara has been a tremendous help to the people of this country and Canada, by increasing domestic and civic convenience and aiding industrial development.

I believe you will all agree that all the 20,000 cu. ft. per second of the flow of the Niagara River allowed us by treaty between United States and Great Britain, should be used and also that the 4400 cu. ft. of this amount not now being used is a big mistake, as it is a wasted available and desired resource of this country.

I believe you will all agree that every cubic foot of water in the Niagara River that is not needed to maintain the scenic beauty and grandeur of the falls should be put to useful work.

The big question is how many cubic feet of water can be diverted from the falls without diminishing their beauty and grandeur. After several years of careful measurement and observation of some able government engineers, they decided that 25 per cent of the entire water of this river could be diverted without detriment, and on their reports the amounts set forth in the present treaty were determined. Over 21 per cent of the normal flow of the river is now being used and no appreciable diminishing of their beauty is noticeable, and it is very evident that much more can be used without detriment.

An eminent engineer living at Niagara, who has made a careful study of the effect of flow condition on the scenic feature, believes that by proper placing of submerged dams above the falls, 50 per cent of the normal flow can be diverted without detriment to the scenic beauty. If he is right, what a crime is being perpetuated on our natural resources! An additional 25 per cent of the flow of Niagara River at the falls represents about one million horsepower, or, if developed by steam, the use of about six and one-half million tons of coal per year. Shall we continue to let this water run to waste?

Strenuous efforts should be made by our government to help get this water in use, instead of the present methods of restricting it.

If the use of water in excess of that allowed by the present treaty is contemplated, there are many existing interests which should be considered.

But who will take the initiative?

As a suggestion, why shouldn't Congress arrange for the invitation of a commission to investigate the further diversion and use of water from the Falls to the full amount possible, still maintaining the scenic beauty and grandeur and without harm to navigation; then have it make recommendations to the United States and Canada for further action.

This commission could be made up of representatives of the various interests involved, such as one from the Dominion of Canada engineers and one from the United States Government engineers, one from Canada and one from the United States representing the public interest in the scenic grandeur of the Falls, one from each country representing the existing power companies, one from each country representing industries using Niagara power and one from each country representing navigation interests, also one from each country of the members of the International Joint Commission.

The Commissioners should be empowered by the interests they represent to energetically spend as much time and money as is necessary to obtain proper information and engineering data required, on which to base their recommendation to the two governments.

I wish to submit this for your consideration.

Mr. F. A. LIDBURY, manager of the Oldbury Electrochemical Company and a past president of the American Electrochemical Society, spoke as follows:

Our guests to-day may have noticed that the speeches and in general the talks they have heard possibly differ in one important respect from those they are accustomed to hear when they visit specific localities on specific problems. I think we can claim there has been nothing local, nothing sectional, presented to-day. We have tried to present this as a national matter, a matter of extreme national importance.

There is one very difficult problem in connection with the power situation at Niagara Falls, and that is the problem of getting into the minds of the people at large a thorough understanding of what the power development at Niagara Falls means and has meant to them. There are problems of considerable importance, analogous problems, where this difficulty does not arise, and we have all seen in the last year or so, the problem of the dye industry discussed with a great deal of intelligence, simply because the average individual, the everyday member of the public, understands what the production of dyes in this country means to him and what it means to him to do without it; but it is extremely difficult to get a layman to understand what the electro-chemical production of this city means to him,

though the importance of that production is, I venture to say, several thousand times the importance of the dye stuff industry in this country.

Now, why is that? It is because he is only affected indirectly. Though in everything he does, in every activity he indulges in, from the time he gets up in the morning until he goes to bed, he is enormously benefited by the electrochemical production of this city. He does not know this because he does not eat bleach, and he does not wear phosphorus, and he is only reached indirectly through a number of stages, and he does not know what these stages are.

An attempt has been made by the papers which have been circulated amongst you and the speeches which you have heard to give you a few—and only a few—of the most important lines along which the electrochemical industry has directly and importantly influenced the industries of this country; but it must be realized that a phenomenon that has been one of the most significant things in industry in the last fifteen years cannot be discussed in fifteen minutes. We realized, we electrochemists have come to understand that not the power companies, but we, are the crucial point in this situation, and it is up to us, and it is a matter of duty for us to get before the people and their representatives exactly what we do and what we need. Now, that is what we are trying to do, and it is very difficult; but there is one thing we have to say to you gentlemen, and that is that the American Electrochemical Society, of which the present president and two past presidents are before you to-day, is most anxious to get before you all the information on this subject that it can, and it stands ready to send out representatives at any time to Washington to give you all the information at their disposal at any time you want to send for them. It is impossible to do it in a few minutes' conversation, but we do feel that we have said enough to-day, and these papers that you have got, if you will read them, will show you enough to indicate that this is really not a matter of secondary, but a matter of primary, importance to the people of this country.

I referred to the dye stuff situation and to the general appreciation of the results which will follow any extreme shortage of dye stuffs. The results which would follow an extreme shortage of the electrochemical products made in this town are something that no man here could describe. They would have to be experienced to be understood. The mildest way in which I can put the matter to you gentlemen is this: That if it had not been for the existence of these industries in this town, in the last two years, instead of this country having had an industrial boom, it would have had one of the greatest industrial depressions it ever has experienced. You have only to take what Mr. Tone said in regard to the steel industry to understand what would have been involved.

The electrochemical industry in this country is something of which we ought to be extremely proud. We hear a great deal about Europe being ahead of this country in chemical industries and similar lines, but there is one branch of the chemical industry in which this country has never had to take a back seat to Europe, and that is the electrochemical industry. As has been pointed out, this town is the chief electrochemical center of the world, and in fact some of the most important electrochemical developments were born here. This is particularly true of those industries which have had the widest and most important influence upon industries in general.

Now, we are not only proud of this development in general, but we are proud—and we have a right to be proud—of the resources and energy with which the electrochemical industries of this country, and specifically of this town, have, under conditions of extreme difficulty, in certain respects, come to meet the situation in the way of increased demands or the substitution of one article for another, that has taken place since the war began. It would take too long to describe this, to explain in detail what has been done; but let me refer to just one specific case which involved throwing over one industry in order to bring up the production of ferrosilicon to a point where it could be of considerable assistance to the steel makers, deprived of foreign production.

The one thing I want to bring to your attention is what the present conditions are and what the outlook is. Ever since power restriction measures came into effect, there has been noticed a tendency, which recently has resulted in an acute condition, to shortage of power on the American side of the border here, and increasing prices, and greater stringency in contract conditions. The vital requirement of the electrochemical industry is abundant power and cheap power. Dear power is no good to it. As a result of these conditions, which started to show themselves immediately the power-restricting measures took effect, there was a tendency to the migration of plants which either originally

began operations here or which would have naturally commenced operations here, to other localities; and I want to specifically call your attention to the fact that the majority of those migrated and the most important of them have been to other countries.

As early as 1907 the first fixed nitrogen plant on this continent was projected. That was the American Cyanamid Company. After carefully looking around and seeing what could be done in the way of power sites in the United States, they decided to locate on the Canadian side of the border, just over the river here, and are to-day consuming something over 27,000 hp. in the manufacture of cyanamid, the market for which is entirely in the United States. The two companies which have revolutionized the abrasive industry have found it necessary to move the greater portion of their furnace operations to Canada, and in one case to France. Recently we have seen the Union Carbide Company erecting a plant to consume 100,000 hp. in Norway, and although it is not yet known where the products is destined for, the principal outlet, it is generally understood, will be in this country.

We can only judge the future by the past and by what we see going on before us at present. What we see to-day is a tendency for these industries to leave this locality because of the lack of power, and to go, not to other parts of this country, but to other countries. Now, why is that? Outside of the power that has been developed here and that can be developed here, there are practically no water powers which offer sufficiently favorable conditions, or which show any prospect of offering sufficiently favorable conditions, for these industries; and there is a very good reason for that. There are lots of water power in this country, and I dare say there are lots of power which can be developed cheaply. Most of it is in the West. Now, the electrochemical products which consume this power have to be transported from one section to another. You can carry them just so far economically, and no farther; and it happens that the consumptive outlet for the majority of the products that are made in Niagara Falls, is in the manufacturing districts of the East. That is, of course, natural because these products are fundamentally important ingredients of the products of the most important industries of the country; consequently, to locate out West is to put a prohibitive transportation cost on the materials; in fact, calculations show that for the purpose of supplying the Eastern markets, the majority of the processes now at the Falls would have to get the power on the Western coast, not only for nothing, but would have to get as much as a bonus as they have to pay for power here!

So if industries move to other parts of the country, they have to go to localities from which they can transport their products cheaply to the manufacturing centers of the East; hence, their location in Canada, particularly those portions of Canada which are near the border here, and which have water transportation, and their location in places such as Norway, from which water transportation is cheap and easy to the Eastern seaboard of the United States. Bad as power conditions now are here, they are likely to become worse. The Dominion Government has reduced the amount of power for which Canadian export permits are given and has served notice of its intention to reduce the exported quantities yearly at a rate which will bring exportation to a complete stop in the course of six or seven years. As at least one-third of the Niagara power used in the United States has been imported from Canada, we are faced with a further curtailment of our already restricted operations. Unless immediate and substantial relief is given, the already insufficient output of our electrochemical plants will be seriously and steadily reduced.

Now, gentlemen, here is the question that we have got to face. Are we going to utilize our natural resources in this country to permit of the further normal development of these industries, which are of fundamental importance to every one of us, or are we going to close our eyes and let things take their course and see these industries gradually expatriate themselves? We have our choice. There is no third way. We have got to make up our minds that we have either got to develop these industries in this country or see them go abroad. It is easy to keep them. All we have got to do is to utilize, instead of allowing to go to waste, those natural resources which have been given to us and which cost us nothing. I think enough has been said to-day to give you an idea of what the frightful consequences may be if such another dislocation of the world's trade comes—if we get into a war ourselves, or if other nations going to war dislocate the world's trade—if we have allowed these industries which are so fundamentally important to grow up, not where they were born and where they ought to be, but in other countries. That is the proposition which faces us.

Now, I do not think that there is any consideration which

is more important in this regard than an answer to the question so frequently put: What has the country got for the alleged spoilage and destruction of the scenic beauty of Niagara, this, that and the other thing that the alleged vandals have done at Niagara Falls? That answer is simple, plain and emphatic. All of you gentlemen know, and know thoroughly well, the effect of the scientific contributions to industry in the last fifteen or twenty years. You know thoroughly well that by those contributions the productive power of each individual in this country has been enormously increased. If you analyse the nature of these improvements, taking the mechanical industries, for instance, which this country is particularly ahead in, and you find that the ability of one man to produce to-day what several men produced before is due—what to? To the contribution of the electrochemical industry to tool steels and to the technique and materials of grinding. The same thing—dependence on the products of Niagara power is true in practically all the industries which have so enormously been improved in the last twenty years, and whose improvements by adding so greatly to the productive power of the individual, have enabled every man in the country to obtain a better and richer existence. That, gentlemen, is our answer to the question: What have you vandals done with Niagara Falls?

Dr. EDWARD ACHESON, the world-famous inventor of carborundum and artificial graphite, was the last speaker. His speech deserves to be called a classic:

Mr. Chairman and Gentlemen of the Foreign Affairs Committee of the House of Representatives:—I understand the purpose of your present visit to Niagara Falls is to give you an opportunity to form a clear and accurate judgment for or against the advisability of permitting a further diversion of water from the Niagara River for power purposes, and, further, its bearing upon the international relations between the United States and Canada.

I have been honored with an invitation to address you, and it is with great pleasure I grasp the opportunity to place before you a few facts which, I hope, you will consider of sufficient importance to bear weight in the formation of your decision.

With your kind permission, I will give you a brief glance at my own activities in and about Niagara Falls, and the results I have been able to accomplish, my excuse for presenting my own affairs to you being that I know them better than my neighbors. There are, however, many other manufacturers who could advance equally strong arguments as those I am about to place before you.

In 1894 I was located in Monongahela City, in the very heart of the bituminous coal fields of Pennsylvania. I was operating a small plant manufacturing carborundum, the production during that year amounting to 52,190 lb. The electrical power for the operation of the furnace, in which carborundum was produced, cost too much money to permit of the material being sold for general grinding purposes.

The first electric power plant erected at Niagara Falls was approaching completion. I came to this city and contracted for 1000 electrical horsepower, built a plant, and during the year 1896 the production of carborundum jumped up to 1,100,000 lb. During the following years the business grew until, during 1913, the production amounted to 20,033,000 lb. Since 1913, the business has shown considerable fluctuation, having dropped to 16,410,100 lb. in 1915, but during the present year—1916—it is running at the rate of 22,433,600 lb., this being the maximum possible production of the plant under the present curtailed condition of power production.

While you will notice that the production in 1916 shows an increase of 38 per cent over 1915, during this year the orders have been coming in to the Carborundum Company at such a rate as to represent an increase of 120 per cent over that of 1915. Notwithstanding these facts, the company has not increased the price of its goods.

It will not be necessary for me to comment upon the great value of this grinding material in the manufacturing world, it now being practically a necessity in many lines of manufacture.

My second venture in commercial manufacture at Niagara occurred in 1900, 16 years ago. It consisted of the manufacture of artificial graphite. The development of this new business has been as follows:

In 1900 the production amounted to 860,750 lb. The following year it had jumped to 2,500,000 lb., and in 1913 it was 13,633,342 lb. This business, you will notice, was developed before the European war had taken form; hence, it had not been influenced by these world disturbances.

Since the beginning of this present year, 1916, the orders for graphite received by the Acheson Graphite Company

have been at the rate of approximately 50,000,000 lb. per year. The company's present plant has a maximum capacity of 40,000,000 lb. per year; while owing to the unfortunate curtailment of power production, only sufficient power can be obtained to produce approximately 20,000,000 lb., and the company faces the further unfortunate condition of possibly being reduced to two-thirds its present output, or 14,000,000 lb., by reason of the Canadian Government having called for a large amount of power now being utilized in the United States.

Let us more closely examine these orders for 50,000,000 lb. of artificial graphite. They are for a material that did not exist 16 years ago. The coming into being of this material has permitted the creation of vast enterprises previously impossible. For instance, as an example, we will take the manufacture of caustic, bleach and chlorine, all important to our present-day life. Competent authorities have stated that their efficient manufacture would not be possible did the artificial graphite not exist. The existence of this Niagara-made graphite has been of incalculable value in hastening the liberation of the United States from the necessity of buying foreign-made products essential to our welfare and growth.

Alongside of and coincident with the growth of these domestic values, is the fact that no less than 29 per cent of this year's business of the Acheson Graphite Company is export trade. Further, these orders from abroad would have been vastly greater had it been possible to fill orders that could be had for the mere asking, and this is happening at the very time Norway, with her great water powers, is becoming restless and shows signs of wishing to enter the world's market with an artificial graphite.

Is it not worth while caring for this export trade? We are at this moment witnessing a great movement of the American manufacturing world towards the creation of a vast export trade. The Government is taking a friendly interest in this movement. Are these Niagara Falls interests too small to be taken into account?

You are, perhaps, thinking and may say I am an interested party, and am only hoping to advance my own interests, but it is possible you may not think so badly of me when I tell you the Acheson Graphite Company has not advanced its selling price one cent since this on-rush of orders. No advantage has been taken of the present great demands for its products.

My purpose in giving you statistics regarding these enterprises is not with the hope of your rendering me assistance to advance my own interests, except as they may be advanced with others. I am presenting them to illustrate what may be done with Niagara Falls power in furthering the interests of our country at large. Many of the products produced in this city are absolutely essential to the successful operation of industries in cities and towns far removed from Niagara Falls.

You may say this is all very good, but why not manufacture these materials somewhere else and preserve the Falls? This brings us to the very heart of this whole matter. Previous speakers have already answered this question better than I am prepared to do. This subject is, however, very much greater than the simple matter of supplying more power and greater facilities to the factories of Niagara Falls. It is nation-wide in importance. You, as a Committee of the National Congress, have a duty to perform and a great responsibility rests upon you.

While you are with us, you will not fail to be impressed with the fact that this is a novel industrial community. Niagara Falls is no longer the pleasure resort of former years. The scenic beauty of the Falls is still with us, but the true value of the Falls and this community, in so far as the country at large is concerned, consists in the vast quantities of manufactured products distributed throughout the world from our local factories, many of which were only made possible of commercial production by the generation of electricity through the diversion of water from the Niagara, and in the invisible, vibrating current of power sent out on radiating threads of copper to cities, towns, and villages within a radius of 100 and more miles. Many of the factories located here on account of the power being cheaper. They have grown to large magnitude, and it is not an easy matter to move them to other localities.

I wish I had the gift of ready language, that I might better impress you with what appears to me to be your opportunity to use your great influence and directing power in bringing about a movement which would be of incalculable benefit to our entire country, and more particularly to our posterity. Would that I might make one small remark that would cause you to depart from what, to me, seems a wicked course—the failure to properly use our great natural resources. We are at the present moment within hearing of the roar of one of the most stupendous forces in the

world. Magnificent and grand from the scenic point of view it certainly is, but to me it would be much grander and more impressive were a large portion of this vast power being utilized for the present and future welfare of man.

I consider it a veritable crime against our posterity to preserve this great natural, inexhaustible resource in its entirety, or as it now is, for reason of its scenic beauty while we at the same time press forward to the exhaustion of the coal deposits of our country.

We are advised our coal supply will be exhausted in another century. Certainly a goodly time, but still not great as we measure the life of nations. There is nothing visionary or fanciful about this early exhaustion of our coal supply. True, we are told of immense coal fields in Alaska, but one cannot readily imagine the factories of New York, Pennsylvania, Ohio, or, in fact, any of the States being supplied from these deposits in the frozen North. Let me impress upon you the fact that a century is not a long period. Three generations will more than cover it. An instance in my own family will well illustrate this. Among the treasures of the family is an invitation from President Washington to one of my grandfathers to dine with him, my grandfather at that time being a member of the Pennsylvania Legislature, and this was more than a century ago. Our own grandchildren may witness the practical exhaustion of our coal if no steps are taken to conserve it.

I have here a few statistics coming from the U. S. Geological Survey: The production of anthracite coal in 1913 was 91,524,927 metric tons. Compare these figures with the production in 1820, which I find was no more than 365 tons, and this was two years after the birth of my father. Here are figures on the production of bituminous coal in the United States: In 1895 it amounted to 124,627,000 metric tons. In 1900 it had increased to 191,256,000 tons, and in 1913 it had jumped to the great figure of 478,523,000 metric tons. You will not find it difficult to see the exhaustion of the coal deposits a century hence.

Perhaps you are not interested in the welfare of the people who will live a century hence, but I assure you that if those people find that a great natural, inexhaustible resource for power, as is the Falls of Niagara, has been preserved to them on account of its scenic beauty, while at the same time the country has been denuded of its coal supply to produce power, these far-away people will be very, very much interested in what you and all of us, of this present generation, have been doing. Unless we have already done so, they will find themselves under the necessity of diverting the water from the river for power purposes; hence they will have neither coal, which we will have used, nor scenic beauty, which we are trying to preserve.

In closing, gentlemen, permit me to leave with you the question, "*What is the true, the real conservation of our natural resources? Is it not the full and economic use of the inexhaustible for the preservation of the exhaustible?*"

The Coal-tar Dye Industry, Past, Present and Future*

BY BERNHARD C. HESSE

For the past twenty years or thereabouts the United States has had within its borders a supply of coal-tar materials of suitable quality and in sufficient amount to produce all of its own requirements of coal-tar dyes if it so chose to use them; for the same period of time it has had domestic access to substantially all the needful other or auxiliary chemicals, except sodium nitrate, in which respect it was dependent upon Chile, and in that regard it was in the same position as practically every other nation; to-day we are in most favorable position in these respects. So far as men, experience and equipment are concerned we are now in better condition than ever before.

In the early days of the coal-tar industry, Belgium, France, and Great Britain had the largest domestic supplies of coal tar and other materials, whereas Germany was not so situated, but was dependent upon these three countries for the major portion of these materials. The coal-tar dye industry was started in England and France fully four years before it was

started in Germany; within the first fourteen years of its life, i.e. by 1874, the German coal-tar dye industry made 90 per cent of the coal-tar dyes then consumed in the world.

From the comparatively small number of dyes which constituted the coal-tar dye industry of 1874, say 50 different dyes, this industry has now grown to more than 900 different dyes, involving more than 300 other chemical products, themselves not dyes, but needful in the making of the dyes proper. The activities that led to the development of the dye industry brought about with them phenomenal development in synthetic medicinal, and pharmaceutical products, synthetic perfumes, photographic chemicals, explosives, disinfectants, and means of scientific study and investigation which were not foreseeable a half century ago. Collateral thereto, but none the less important, the technique, information, and point of view so evolved has had a mighty and stimulating effect upon many other branches of chemical-industrial endeavor all outside coal-tar chemistry. Few, if any, chemical activities have been so catholic in their fields of endeavor and so all-pervading in their effects.

Fifty years ago the commercial future of the coal-tar dye industry seemed limited; its possibilities, direct and indirect, did not appeal with any great force to any but the Germans; the industry as it stands to-day is a monument to constructive imagination, a willingness to make and market small amounts, dogged persistence, and the very perfection of salesmanship and operating organization. With but one exception, alizarin, the whole industry must then have seemed as though it would never outgrow the "pot and kettle" stage, that is, manufacture in small units—a "toy" industry, in other words.

In 1913, Germany had twenty-two going concerns making coal-tar dyes; these are the survivors among thirty-nine concerns, of which eleven were abandoned and six were absorbed.

The latest figures available for Germany's export business in normal times are those for 1913; in that year Germany exported 120,000 short tons of dyes having a declared export value of \$51,640,000, or \$430 per ton, or 21.5c. per lb. In the same year Germany exported intermediates to the extent of 22,000 short tons, of a declared export value of \$4,310,000, or \$196 per short ton, or 9.8c. per lb.

In the mass, these are stupendous figures, totaling 142,000 short tons and \$55,950,000, or an average value of \$394 per ton, or 19.5c. per lb. On closer inspection it will be found that for the more than 1200 things that have to be made, this means an average of not more than 118 tons per year, or \$46,625 per year per product for the entire world outside of Germany; at 300 days per year this means on the average not more than 790 lbs., or \$155 per day per product, for the entire world outside of Germany.

The dividends declared and distributed in 1912 by 21 of the German coal-tar dye manufacturers amounted to \$11,600,000. The 1913 dividends were about the same as those for 1912. Of the twenty-two plants of 1913, one declared no dividend and four sustained a loss amounting to about 8 per cent of their capitalization. Per product, these 1912 distributed dividends amount to not more than \$9,700, and these dividends included whatever of profits these concerns made as distributors and makers of their wares, including heavy chemicals, dyes, intermediates, photographic chemicals, synthetic medicinals and pharmaceuticals, explosives, and the like, all inclusive of Germany's own consumption of all these articles. If the German consumption be taken at twice the United States importation in 1913, this makes Ger-

*An address delivered on July 18, 1916, at the Mid-Year Meeting, Jobbers' Association of Dress Fabric Buyers.

many's total production in 1913 about \$78,000,000; \$11,600,000 in dividends means not more than one dollar in dividends on each \$6.72 of turnover, or not more than 15 per cent on the turnover.

If proper allowance be made for the large individual articles of consumption, the average annual value, output, and profit for the remaining things becomes very much less than above given, and perhaps only 60 per cent of the above average figures, say to 475 lb. or \$90 per day gross per product for all the world outside of Germany.

At \$15,000,000 for the manufacturers' value of all coal-tar dyes consumed in the United States in normal times—and this is a very liberal figure—this means 15c. per year for each of the 100,000,000 inhabitants of this country; for each person in this country to average a consumption of 1c. for each of the present-day 1200 dyes and things needful in making these dyes—i. e., \$12—would take 80 years.

From the point of view of average individual annual tonnages, gross receipts, distributed dividends, or individual personal consumption, there is firm ground for the opinion that even to-day the coal-tar dye industry, big as it is in the mass, is still, in great measure, a "pot and kettle" affair, a "toy" industry, or a "department-store" aggregation of many small units, and that in mercantile reality and in total effect it is just about a "one-nation" business.

In 1913 there were probably not over 40,000 people all told engaged, in the whole world, in the manufacture of coal-tar dyes and of the chemicals needed therefor, apart from making and distilling coal-tar in itself. The entire indigo consumption of the world, which is the largest single item in the whole business, probably can be produced with not more than 1500 men all told. Taking our own total consumption of coal-tar dyes of all kinds as one-seventh of the world's total, 6000 people could reasonably be expected to be the maximum number needed for its production. In 1914, our railroads hauled 1,000,000,000 tons of freight; our dye consumption is about 30,000 tons per year; to make these here would probably not add 60,000 tons to the country's freight haulage, or 0.006 per cent. If we made all and the whole of our own dyes, that would diminish our total national merchandise import business by about 0.5 per cent. Assuming the dividends to be apportioned as above, this would mean about \$1,660,000 of added dividends.

So, from the point of view of added labor, freight haulage, diminution of our foreign business, and added dividends, if we made all our own dyes within the country the project does not seem to be a strikingly alluring one from a national outlook.

Among all the branches of the chemical industry of Germany, the coal-tar dye industry is the greatest of dividend payers, paying ten points more in dividends than any other branch. It sells its products in thirty-three countries outside of Germany, and therefore has its eggs distributed among many different baskets.

In any plans we may make for bringing about our independence of any foreign country for coal-tar dyes, medicinals, and other useful like products, we must take all the foregoing facts and deductions into account, and provide for them and their consequences so far as we can reasonably foresee them.

Why should we be thus independent? In the tariff revision of 1883, dependence upon other countries was avowedly, eagerly and deliberately advocated and accepted, among other reasons given being that we could never build up the coal-tar dye industry here, and that the import duty raised the price of

red-flannel shirts 25c. per dozen and the price of an average-sized rag carpet 3 or 4c. In 1908 there were seventeen New England cotton establishments protesting collectively against any tariff increase, because that would increase the cost of manufacturing colored cotton goods in the United States and the price to the consumer in the United States; and in the case of export trade, an advance in the cost of any of their raw materials adds to their burdens and minimizes their opportunity to compete with foreign cotton manufacturers in foreign markets.

In the 1913 tariff revision, southern cotton mills took substantially the same position. In the record of the hearings on the Hill bill, held Jan. 14 and 15, 1916, some of the seventeen signers of 1908 reversed themselves either in writing or orally. Those who have so reversed themselves represent about one-third of the total labor, power, and textile-machinery capacity of the seventeen, and probably the same proportion of the total capital. Since then others may have reversed themselves, but, if so, that fact has escaped me.

Thus, from 1883 to 1913, coal-tar dyes were regarded as raw materials, and as such they should be free, or taxed but little. Whatever import duty was assessed during that period of time did not in any way encourage or foster an American coal-tar dye industry and did not interfere with our avowed purpose to be dependent upon others in this regard; all this in the face of continued, repeated, and elaborate protests against such a course by those then engaged in making dyes in this country. The probable effect of a European war upon our industries using foreign-made dyes was discussed in July, 1882, as follows: "These goods are made not only in England, but in Germany, and if the worst comes to the worst, and we were cut off from our European supplies, we could fall back on the vegetable dyes that came from South and Central America before aniline dyes were invented."

The 1883 tariff cut closed many of the then existing nine American coal-tar dye plants; to some of the individuals it meant ruin. If, as a result of the present-day cry for re-establishment of this industry a new tariff is enacted and men for that reason engage in this venture, the nation must keep faith and its implied covenant, and not leave these men in the lurch; we must never backslide merely because we then find the actual cost higher than in our present state of mind we believe it will be or think we are prepared to pay. Let us be absolutely clear in our own minds and sure of ourselves. If we decide to go forward—never let us turn back.

Ever since 1883 a specific tax has not been assessed; an ad valorem duty and ranging from 25 to 35 per cent, now 30 per cent, and that on a part only, not all dyes made from coal tar. As a matter of fact, we have not had a real domestic coal-tar dye industry—merely an assembling industry; that is about all the tariff can be said to have effected.

In the year 1913, Germany sent us, in round numbers, \$7,300,000 of so-called aniline dyes dutiable at 30 per cent; \$2,800,000 of alizarin and anthracene dyes and indigo, not dutiable; and \$1,086,300 of intermediates, dutiable at 10 per cent. These are the rates of the present Underwood tariff, effective October 3, 1913.

Taking these figures and rates as a basis, the total revenue thus assessable and collectible would amount to \$2,298,632; under the Hill bill provisions this would have been \$6,908,648; and under the Kitchin bill provisions this would amount to \$4,999,084; the increases over the Underwood tariff being for the Hill bill \$4,610,016, and for the Kitchin bill \$2,700,452; that is, where the Hill bill contemplates adding \$1.00 the

Kitchin bill contemplates adding 59c. In other words, where Underwood adds \$1.00 to the export value the Hill bill adds \$3.00 and the Kitchin bill \$2.18, assuming for the purpose of this comparison that the duty imposed will appear entirely as added cost to the consumer, which may or may not be the case.

We know that the Underwood dollar did not create a dye industry. We are led to believe by informed persons, acting upon honor and entirely disinterestedly, that the Hill bill's \$3.00 will probably create a complete self-contained and self-sustaining industry in this country, which will make not only coal-tar dyes and explosives, but also all the many other things obtainable from coal tar and other like materials, and that anything less than that is not likely to lead to any substantial industry. With this view the most experienced domestic coal-tar dye makers agree.

The Kitchin bill proceeds from the admission and premise that the Underwood and all like dollars created no industry to the conclusion that \$2.18 will create a complete self-contained and self-sustaining industry in this country. We know that the Underwood dollar, and all similar preceding dollars, might just as well have been thrown into the sea for all the real domestic industry they created; the Kitchin bill's \$2.18 may merely be throwing good money after bad; we are told that the Hill bill's \$3.00 may be the same, but not probably. That is the dollars-and-cents view of the proposed legislation at Washington.

Again, we are similarly told that protection in order to protect this industry must protect it all the way round. The Hill bill does that; the Kitchin bill does not. If you were building a high board fence round your vegetable garden to keep your neighbors' chickens out, would you build three-quarters of the fence so that it went well into the ground, and leave the other quarter 3 ft. from the ground, on the theory that the chickens would not find this weak spot in your fence? In exempting anthracene, alizarin and indigo dyes and indigo from the surtax, that is precisely the theory on which the Kitchin bill proceeds, and it offers, at the suspended portion of the fence, an added bait for the chickens, by threatening to remove the surtax unless 60 per cent of the value of our total consumption is produced in this country within five years. That is about the same as if, in addition to building the fence as just described, you industriously sprinkled a lot of "chicken feed" so that it leads directly to this hole in your fence. That is the strategy of the Kitchin bill.

How shall the domestic value be computed? Shall the foreigner be allowed to add to his invoice value, duty, surtax, and any other usual charges? If so, he is given a considerable advantage over and beyond the 27 per cent start the Kitchin bill proposes to give him; this start may become 35 per cent and all the foreigners have to do would be less than 5 per cent additional work.

The Kitchin bill and the Hill bill each proceeds from the fundamental proposition that unless we protect the coal-tar dye and chemical industry in this country we are not going to have any such industry. That proposition may therefore be accepted as being true, conclusively established and the permanent consensus of public opinion; since it is indorsed by both the Democratic and Republican parties, free trade and protectionist alike. The only reasonable conclusion from this is that both political parties and the public each and all stand affirmatively committed to the national need of a coal-tar chemical industry in this country that shall be permanent, complete, self-sustaining, independent and fully capable of self-development; anything less than that would be a mere makeshift and a Dead Sea apple.

In the case of a given typical example of a cheap and

widely used coal-tar dye the Hill bill contemplates a net added protection ranging from 3.44c. to 2.95c. per lb.; the Kitchin bill contemplates a net added protection ranging from 2.08c. to 1.59c. per lb.; the American dye makers in 1908 wanted a net added protection of 3c. per lb. for that general class of dyes. The Hill bill gives the dye maker what he says he needs; the Kitchin bill does not. If we *really* want an American coal-tar dye industry and all it brings and may bring with it, why should we thus haggle? The reason seems to be that we fear that the Hill bill rates will create a set of "tariff robbers," and the assumption is that the Kitchin bill will not. Once we have a domestic dye industry we ought to be able to handle the "tariff robber" question on its merits, or are we so to confess that the only way we can check "tariff robbers" is not to have an industry?

Further, the Kitchin bill thinks that this protection might cost as much as \$2,700,000 per year; the Hill bill thinks this cost to be \$4,610,000 per year—either one a tidy sum, even for this nation and one which we should not light-heartedly incur.

Now, *why* should we have it? Surely not to add 6,000 people to our laboring population; this would be \$450 per year per person under the Kitchin bill and \$768 under the Hill bill. Surely not for 60,000 tons additional freight haulage, for this would be per ton of freight \$45 under the Kitchin bill and \$77 under the Hill bill; nor would it be good business to pay either sum so that certain stockholders could get \$1,660,000 per year in dividends. It cannot be a dollars-and-cents reason in this direction.

The Hill bill and the Kitchin bill were both introduced into Congress because of the insistence of dye-using interests that something be done to relieve the dye shortage and not at the request of dye-makers. These same interests for thirty years had kept down the duty on dyes, and were almost solely responsible for the disastrous tariff cut of 1883; the dye-using interests therefore have almost complete control of the dye-tariff policy of this country, and the dye and chemical making interests have no such control—not even a reasonable hearing. Under these circumstances it is reasonably clear that the dye-using interests can have any duty that may now be added removed at their pleasure. It is not sound, national policy to attempt to build up an industry in this country by protective legislation when the profits in that industry for some time will be dependent upon such protection and then have the power of altering that protective policy lodged exclusively in the hands of the customers of that industry to be exercised at their pleasure and in their interests only. When the situation is relieved why should they not have the duty removed? If they decided on that course the dye and chemical makers might be just as helpless to prevent it as they were in 1882 and continued to be down to 1913 and are, in fact, to-day.

It is true that the dye users also insist that arrangements shall be made so that such shortage cannot recur; but might they not brush that aside just as in 1882?

The *Journal of Commerce* of New York, on April 24, 1916, said:

"In the meantime dyes have been offered and sold here at fabulous prices in quantities palpably sufficient to keep all the largest textile plants moving. Somewhere and somehow supplies of dyes have been secured, for never before in the history of the United States textile industries have plants been run so full as they have been in the past six months, whether plants for printing, finishing and dyeing."

So that, from about the end of October, 1915, there has been no scarcity of dyes—provided you paid the price. Is that a "famine" or just a "corner"?

Had cotton not dropped violently in price in August, 1914, or, if you gentlemen had then been willing to pay 15c. for 6-cent cotton, there would not have been any such prompt demand for dyestuff-independence; we would probably not have heard much, if anything, about independence until fully a year later, if then. By so widely and publicly using the dye-stuff situation to offset the demoralized cotton market the cotton manufacturers simply invited others to come in and "corner" the dyes, which seems to have been efficiently done.

In now demanding that this country should never have been dependent upon others and that the dye-shortage, famine or corner, whatever you may choose to call it, should not have been permitted to exist, the dye-using interests are merely complaining against the logical, clearly foreseeable, but deliberately ignored results of their own deliberate and concerted acts.

To engage upon business merely to relieve a famine, real or artificial, is not attractive to anyone; to enter upon it to establish it upon a sound permanent basis is quite another thing. Frankly, all that the dye-using interests can safely be counted upon for is to want to relieve the situation, and they do not care how it is relieved—beyond that all is uncertainty, with the chances in favor of their successfully abandoning their desire for a strong domestic industry so soon as they can see reasonably clearly ahead for themselves, regardless of what the dye and chemical makers may think of the then existing conditions.

Legislation to foster this industry can be no more lasting than the reason for its existence. None of the reasons so far discussed can truthfully be said to promise sufficiently long life to achieve that result. They have all been successfully used in the past to prevent such protection; they are now urged to create such protection; there is no reason to believe that they will not revert to their former purpose at the very first opportunity, and that will no doubt come long before the industry is safely established.

These reasons touch relatively few of us. The question of having at all times equipment in this country and men capable to operate it to produce means of national defense, i.e., high explosives, is one which promises to affect all of us. Now, what could a complete, self-contained and self-sustaining domestic dye industry making our total requirements of dyes so contribute? The most we could reasonably expect from it is that in a comparatively short time, say, a month or less, it could turn out 100 tons high explosive per day and could train enough chemists, superintendents, foremen and workmen fast enough properly to operate additional high-explosive-making plants as erected. In the past eighteen or twenty months we have learned, with every possible stimulus, to build from the ground up plants capable of making 80 tons of picric acid per day. How much TNT is made daily is not known to me with any certainty. From that point of view this contribution seems reasonably worth while. If we make 60 per cent of our requirements we very likely would make 60 tons in place of the 100 tons high explosive per day.

The massed coast artillery of our Atlantic and Pacific seaboard has to-day such a capacity of firing projectiles that if 5 per cent of the weight of those projectiles were high explosive, 100 tons high explosive, or one day's output, would last seven minutes. On the same basis, assumed the high-explosive producing capacity of the German coal-tar industry, as it existed just before the war, would last fifty minutes, or perhaps an hour.

Is it worth our while to have such a dormant capacity in this country? In a month we could then reasonably expect to be where otherwise we might not be much under a year? I think so.

If the final answer to that question be an equivocal "yes," and our army and navy officials are the only persons to answer that question in a way that would surely have the confidence of the public, then we have a reason for this special protective legislation that would be far more stable and far less subject to change than any other reason yet given. Such legislation would not be repealed nor altered for trade reasons alone; it would not be repealed until the coal-tar dye industry were really firmly established and we really did have this dormant capacity firmly under our own control. Surely we cannot be so impotent as a people, that we cannot devise ways and means successfully to resist "tariff robbers" and prevent their exploiting us under this kind of a cloak!

The same attitude should be taken if the answer be anything less than an unequivocal "no." In case of doubt play safe. It is better to be safe than sorry.

I have devoted so much time to a consideration of pending Federal legislation and to the precise location of the exact cause of all our dyestuff troubles because the future of the coal-tar dye industry in this country depends upon what and why legislation is enacted. It is no time for half-hearted measures. Either we have the substantial whole of the industry or we will have nothing of value in time of stress.

There is no reasonable question as to the wonderful expansion of coal tar and allied chemistry in the future. Fifty years ago no one would or could have dreamed of an industry of its present day magnitude—an industry that underlies so much of our textile, leather, printing, decorative and other industries; that is such a fundamental part of the great photographic industry; that provides remedies and medicines that reach to every hospital and almost every sickbed in the civilized world and adds to our comfort and well-being in such a multitude of directions as this industry does, and which also supplies so much and so many things to national defense. The best of these have not yet been discovered. There is much room for improvement. Just think of the advance in these lines during the past twenty years. Fifty, even twenty, years from now this combined industry may have grown so that its present permeation of the industrial life of nations will appear as a dwarf by comparison with its then influence.

Had we had a going dye industry in this country at the end of the 90's or early this century there is every reason to believe that we, too, would have been successful makers of the so-called vat dyes that make the wonderfully fast modern shades and would have had a substantial share in the making of all the other dyes and their intermediates and progenies.

The longer we delay getting this industry the more difficult the task will become. Shall we continue to sit by, let others do the work and reap the benefit and continue to be dependent upon others for all these things which are bound to become more numerous and more ramified than ever? There is no question that we can, if we will, make just as good qualities as anyone. We cannot do it unless we have the opportunity to acquire the experience. Shall we continue to be denied the opportunity, or does the nation want these things and actually want them earnestly enough to face the situation and pay the price without quibble and without haggle?

Great as has been our domestic progress in the past two years we cannot hope to keep it all without substantial economic help; to think that we will lose it all even without added help has no foundation in reason. Without help, and real help at that, we will continue to have, in normal times, an industry which is far from complete, and self-sustaining and self-developing and

bound to be a disappointment in time of stress and trial.

Now, which shall it be? The Hill bill, with reasonable certainty of success, or the Kitchin bill, with far less reasonable chance for success? The difference between the two may very well be the difference between substantial success and substantial failure. The differences in cost of finished fabric cannot be great—in most cases far from being large enough to pass along. In those few cases where the added cost turns out to be greater than can be borne they can be taken care of otherwise, and if necessary by needful tariff help. Certainly the difference in cost of finished fabric between the Hill bill and the Kitchin bill can hardly ever be large enough to pass along.

My own view is this: If the country is really honest and sincere in its loud and prolonged clamor for independence in this regard, now is the time to prove it by deeds. Plain, ordinary square-dealing and horse-sense clearly and imperatively demand the prompt enactment of the Hill bill rates, under which it will be none too easy sledding. The Hill bill rates are those that domestic dye-makers say are absolutely necessary to achieve this independence.

The dye users from 1882 to 1913 have deliberately and successfully played right into the hands of foreign dye-makers and against domestic dye-makers, and there is every reason to believe that they have not yet entirely overcome that habit. The Kitchin bill is the Hill bill pared down, cut down, and ham-strung, solely in the interest of dye users. Such quibbling, haggling and cheese-paring do not square with common sense, nor sincerity nor with fair-dealing toward the dye-makers who will have to carry the load. Even if, in years to come, the Hill bill should allow the existence of "tariff robbers" we can cross that bridge when we get to it.

The first thing to do is to get this industry; we can then take care of "tariff robbers," if and when there are any, if we want to.

If we choose the Kitchin bill and success should not attend it we will have lost just so much time and effort and will merely have shown again and for the sixth time that the dye-using interests cannot successfully prescribe tariff rates for the dye-makers. If we choose the Hill bill we will be giving the dye-makers their first real chance at tariff-shaping and also that which they say will enable them to create the complete and independent industry in all its substantial ramifications. If they then fail to create this industry it will be because the very best conclusion they could draw from the past failed to meet the then situation, and we will be better able to make the next step for success.

There is no less chance of encouraging rapacity on the part of the dye-makers under the Kitchin bill, should success attend it, than under the Hill bill should it be successful.

In summary, then, the coal-tar dye industry of the present has grown from obscure beginnings of little real world-wide promise to an industry that is of very wide ramifications in almost every phase of national and international commerce and industry. Experience in the past has shown that in order to get a foothold and develop in this country it must be aided substantially. We have had only an assembling industry. At present we have made great progress much of which will remain with us no matter if the present tariff be changed or not, but it will be in essence an assembling industry still. The future of the coal-tar chemical and allied industries is brighter and fuller of promise than ever. Its future in this country lies in our own hands, to make or to mar. Which will we do?

New York Meeting American Chemical Society

A meeting of the American Chemical Society will be held in New York City Sept. 25 to 30, inclusive, simultaneously with the Second National Exposition of Chemical Industries.

The first general meeting is to be held on Tuesday morning, and on Tuesday afternoon it is hoped to have a public meeting in the large hall of the City College with addresses by prominent men bearing upon "Chemistry and the National Welfare." On Tuesday evening a general "get-together" meeting or smoker will be held by the New York Section complimentary to the parent society, to which visiting chemists will be invited. On Thursday evening the American Electrochemical Society will give a smoker to which the members of the American Chemical Society will be invited, and on Friday evening a subscription banquet will be held.

Meetings divisions will be held on Wednesday, Thursday, Friday and Saturday mornings. One of the special features of the meeting will be general conferences on special subjects in which the chemists of the country are now interested. The idea of these conferences is to have some important topics such as Glassware and Porcelain; Steel Alloy Metals; Paper and Its Utilization; Oils and Motor Fuels; Convertibility of Plant; Medicinal Chemicals; Dyestuffs and Their Relation to Munition Factories; Industrial Alcohol, Acetone and Formic Acid. The discussion is to be started by some well-known specialists in these lines. No special program is planned for these conferences, but it is believed that chemists interested in these various lines will get together and many interesting points will be brought out which will be of mutual interest. The topics for these conferences have not yet been determined upon and suggestions are desired from members of the society. These suggestions will all be placed before the program committee and some six or eight topics selected therefrom. It is anticipated that two conferences will be in session each afternoon at the same time, one in the lecture hall of the Chemists' Club and one in the Grand Central Palace, where the Second National Exposition of Chemical Industries will take place.

The president's address will be one of the general papers at the public meeting on Tuesday.

The Divisions of Biological Chemistry, Physical Chemistry and Industrial Chemistry will hold a joint symposium on colloids on Wednesday and Thursday mornings. On Wednesday morning the symposium will be of a theoretical nature, in which the Industrial Division will not take part. On Thursday morning the symposium will be composed of industrial applications to colloid chemistry.

New York Meeting American Electrochemical Society

The thirtieth general meeting of the American Electrochemical Society which will be held in New York City Sept. 28 to 30 inclusive, in conjunction with the Second National Exposition of Chemical Industries, promises to be a most interesting and an exceedingly valuable meeting to attend. On Tuesday evening, Sept. 26, a general reception will be held at the Hotel Astor to which members of the American Electrochemical Society are invited. On Wednesday evening a general reception and registration will be held at the exposition. On Thursday morning will be held the "Made in America" technical session; on Thursday evening a complimentary smoker; on Friday morning a technical session; on Friday evening a joint banquet at the Waldorf-Astoria with the American Chemical Society. On Saturday an excursion may possibly be held.

The Thermal Decomposition of the Aliphatic Hydrocarbon Derivatives of Naphthalene

BY GUSTAV EGLOFF

The thermal decomposition of the pure aromatic hydrocarbons, benzene, toluene, xylene, cymene, naphthalene and anthracene has been studied.¹ The course of reaction due to temperature and pressure changes was found to be as follows: Higher homologs of benzene, lower homologs of benzene, benzene, diphenyl, naphthalene, anthracene, carbon and gas. In the following paper the aliphatic derivatives of naphthalene have been subjected to pressure and temperature conditions to form benzene and toluene.

SCOPE OF THE PRESENT INVESTIGATION

A tar oil resulting from the destructive distillation of coal contains compounds of the aliphatic and aromatic hydrocarbons. Tar acids and bases with naphthalene and anthracene are present in the tar oil. An earlier communication² showed that a tar oil did not decompose readily to form benzene and toluene. It has been found that naphthalene³ and anthracene under thermal and pressure conditions went mainly to gas and carbon, with no appreciable benzene or toluene formation. This did not preclude the possibility of benzene and toluene formation from the tar oil in quantity after extracting tar acids, bases, naphthalene and anthracene, leaving an oil chiefly composed of aliphatic derivatives of naphthalene.⁴ The removal of tar acids, bases, naphthalene and anthracene was necessary if benzene and toluene were to be formed appreciably.

DERIVATION OF THE OIL USED

The oil used was one derived from the thermal decomposition of coal, and is commonly known as a tar oil. This tar oil contained tar acids, bases, naphthalene, anthracene and aliphatic compounds of naphthalene. Table I covers the distillation analysis of the original tar oil.

TABLE I—DISTILLATION ANALYSIS OF ORIGINAL TAR OIL
Specific gravity, 1.007/15.5 deg. C.

Temperature, Deg. C.	Per Cent by Volume	Specific Gravity
125 to 150	4.0	0.860
150 to 200	5.5	0.945
200 to 250	47.0	0.975
250 to 300	26.5	1.005
300 to 350	9.5	1.037
Residue	7.0	
Loss	0.5	

The bases present in the tar oil were removed by treatment with sulphuric acid in the usual manner. The tar acids of the phenol, cresol type were extracted by

TABLE II—ANALYSIS AFTER REMOVAL OF BASES AND TAR ACIDS
Specific gravity, 1.005/15.5 deg. C.

Temperature, Deg. C.	Per Cent by Volume	Specific Gravity
125 to 150	8.4	0.950
150 to 200	62.0	0.999
200 to 250	12.0	1.025
250 to 300	5.0	
300 to 350	12.0	
Residue	0.6	
Loss		

the use of a sodium hydroxide solution. The oil, after bases, tar acid removal analysed as shown in Table II.

After removal of tar acids and bases the oil was

cooled with a salt-ice mixture so as to remove naphthalene and anthracene present. The oil after naphthalene and anthracene extraction gave the distillation analysis of Table III.

TABLE III—ANALYSIS AFTER NAPHTHALENE AND ANTHRACENE REMOVAL
Specific gravity, 1.000/15.5 deg. C.

Temperature, Deg. C.	Per Cent by Volume	Specific Gravity
125 to 150	6.3	0.958
150 to 200	75.0	0.995
200 to 250	15.0	0.999
250 to 300	3.1	0.998
300 to 325	0.6	
Loss		

This oil contained mainly alkyl and alkene derivatives of naphthalene.

EXPERIMENTAL PROCEDURE

The method of thermolizing the oil has been covered by Whitaker and Rittman.⁵ It consisted essentially of an electrically heated tube through which the oil was passed at a definite rate.

The oil was cracked under conditions of pressure and temperature, which gave a liquid widely different in composition from the original. It was analysed for its benzene and toluene content by the specific gravity—distillation method⁶ and also by nitration. The nitro derivatives were determined as the mononitrobenzene and dinitrotoluene. The carbon formed was determined approximately by scraping it from the walls of the cracking tube and by filtering the suspended carbon in the thermolized oil.

The experiments were conducted at temperatures 600° C., 650° C. and 700° C., with pressures ranging from one to fourteen atmospheres.

EXPERIMENTAL DATA

TABLE IV—EFFECT OF TEMPERATURE AND PRESSURE ON THE PER CENT OF RECOVERED OIL AND THE PER CENT OF CARBON FORMATION

Temperature, Deg. C.	Pressure, Atmospheres	Per Cent of Recovered Oil by Volume	Per Cent of Carbon by Weight
600	14	68.5	8.3
650	1	75.0	1.5
650	11	50.0	5.0
650	14	45.0	10.0
700	11	33.6	29.0

TABLE V—EFFECT OF TEMPERATURE AND PRESSURE ON THE PER CENT OF BENZENE AND TOLUENE IN THE RECOVERED OIL

Temperature, Deg. C.	Pressure, Atmospheres	Per Cent Benzene	Per Cent Toluene
600	14	1.5	3.5
650	1	1.2	0.7
650	11	6.0	4.0
650	14	7.0	3.9
700	11	8.5	3.9

TABLE VI—EFFECT OF TEMPERATURE AND PRESSURE ON THE PER CENT OF BENZENE AND TOLUENE ON THE BASIS OF ORIGINAL OIL USED

Temperature, Deg. C.	Pressure, Atmospheres	Per Cent Benzene	Per Cent Toluene
600	14	1.0	2.0
650	1	0.9	0.5
650	11	3.0	2.0
650	14	3.2	1.8
700	11	2.8	1.3

¹Rittman, Byron and Egloff, *Jour. Ind. Eng. Chem.* 7, 1019, 1915.

²Rittman and Egloff, *MET. AND CHEM. ENG.* 14, 15, 1916.

³Loc. cit.

⁴Schulze, *Berichte* 17, 842, 1884. Emmert and Reingruber, *Annalen*, 206, 367, 1880. Lunge, *Coal Tar and Ammonia*, 1909.

⁵Whitaker and Rittman, *Jour. Ind. Eng. Chem.* 6, 383 and 472, 1914.

⁶Egloff and Twomey, *Jour. Phys. Chem.* 20, 121, 1916.

⁷Rittman, Twomey and Egloff, *MET. AND CHEM. ENG.* 13, 632, 1915.

DISCUSSION OF EXPERIMENTAL DATA

A. The effect of temperature and pressure on the per cent of recovered oil and the per cent of carbon formation.

- a. At constant pressure of eleven atmospheres a change of temperature from 650° to 700° C. decreased the per cent of recovered oil from 50 to 33.6 per cent, a difference of 16.4 per cent in the amount of decomposition. At a pressure of fourteen atmospheres and increasing the temperature 50° C. the decrease in the per cent of recovered oil was 23.6. This indicates that greater decomposition takes place at a higher pressure and lower temperature.
- b. At constant temperature of 650° C. a change of pressure from one to fourteen atmospheres gave a greatly increased velocity of decomposition of the original oil. The yield of recovered oil decreased 30 per cent upon increasing the pressure from one to fourteen atmospheres.
- c. The formation of carbon increases with increase of temperature and pressure. In this series of experiments temperature had a greater effect upon the carbon formation than pressure. At constant pressure of eleven atmospheres a temperature difference of 50° C. increased the carbon yield from 5 to 29 per cent. At constant temperature of 650° C. an increase of pressure from one to fourteen atmospheres, the per cent of carbon ranged between 1.5 and 10 per cent. Higher temperatures and pressures would have yielded the ultimate products—carbon and gas.

B. The effect of temperature and pressure on the per cent of benzene and toluene in the recovered oil.

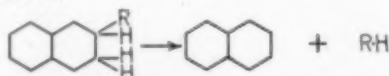
The yield of benzene in the recovered oil increases with increase of temperature, at pressures eleven and fourteen atmospheres. At eleven atmospheres a change of temperature from 650° to 700° C. reduced the per cent of toluene from 4 to 3.9. At constant temperature of 650° C. increase of pressure increased the benzene content, whereas, the toluene reached a maximum and then decreased. Toluene formation is favored by lower pressure and benzene by higher.

C. The effect of temperature and pressure on the per cent of benzene and toluene formation on the basis of original oil used.

At fourteen atmospheres a change of 50° C. increased the yield of benzene from 1 to 3.2 per cent. Under similar conditions the toluene decreased from 2 to 1.8 per cent. A change from 650° to 700° C. and eleven atmospheres decreased the benzene and toluene yield. At constant temperature of 650° C. increase of pressure is favorable for benzene formation but not for toluene. A temperature of 650° C. and fourteen atmospheres is most favorable for benzene, whereas the same temperature and eleven atmospheres gives maximum toluene formation.

THE MECHANISM OF REACTION

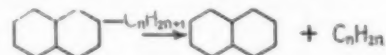
Jones and Wheeler¹⁰ in distilling coal at a temperature below the formation of hydrogen have found aromatic hydrocarbons present in the distillate. In accounting for the presence of aromatic hydrocarbons of the type of naphthalene they assumed the course of the reaction to be as follows:



Brooks¹¹ and coworkers account for the formation of

¹⁰Jones and Wheeler, *Jour. Chem. Soc.* 105, 2562, 1914.
¹¹Brooks and Humphrey, *Jour. Am. Chem. Soc.* 33, 396, 1915.
 Brooks, Bacon, Padgett and Humphrey, *Jour. Ind. Eng. Chem.* 7, 180, 1915. Brooks, *Jour. Franklin Inst.* 180, 653, 1915.

naphthalene by assuming that the naphthalene radical must be present. This assumption is deduced inferentially from decomposing a mixture of phenyl paraffins forming benzene, toluene and unsaturated hydrocarbons. They assume the course of the reaction to be as follows:



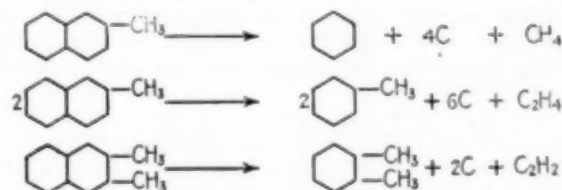
Jones¹² found that under a temperature of 420° C. dihydronaphthalene gave a gas composed mainly of hydrogen and traces of higher olefins and ethylene. Decomposition of tetrahydronaphthalene at a temperature of 530° C. gave in the gas:

	Per Cent by Volume
Benzene and higher olefins	3.6
Ethylene	3.3
Hydrogen	80.5
Methane	9.2
Ethane	4.0

No analysis of liquid, if any resulted, was given.

In the thermal and pressure decomposition of aliphatic derivatives of naphthalene, benzene and toluene being formed the following mechanism of reaction may be assumed as having taken place. Though one must bear in mind that in complex reactions of hydrocarbon mixtures, no one reaction can be looked upon as taking place by itself, secondary and tertiary reactions must take place paralleling the primary.

When Jones¹³ heated di and tetrahydronaphthalene the products in the gas were benzene, ethylene, hydrogen, methane and ethane. Now the starting oil used in this investigation contained monomethyl and dimethyl naphthalenes¹⁴ with higher aliphatic compounds of naphthalene. If one heated monomethyl and dimethyl naphthalene the reaction products can reasonably be expected to take the following course:

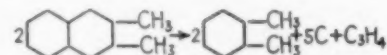


Similar reactions would very likely follow using higher alkyl and alkene compounds of naphthalene.

Secondary reactions taking place at the temperature and pressure to which the oil was subjected would decompose the xylene, forming benzene and toluene. The decomposition of xylene giving benzene and toluene has been determined experimentally.¹⁵



Another direction of decomposing dimethylnaphthalene would be in the formation of allylene.



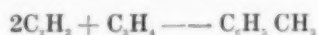
From the researches of Berthelot¹⁶ and other workers in the field of acetylene, it is certain that acetylene polymerizes, forming benzene and other aromatic hydrocarbons.



Jacobsen¹⁷ assumes the higher homolog of acetylene,

¹²Jones, *Jour. Chem. Soc.* 107, 1582, 1915.
¹³Reingruber, *Annalen*, 106, 367, 1884. Schulze, *Berichte*, 17, 842, 1884.
¹⁴Rittman, Byron and Egloff, *Jour. Ind. Eng. Chem.* 7, 1019, 1915.
¹⁵Jacobsen, *Berichte*, 10, 853, 1877.
¹⁶Berthelot, *Ann. Chim. Phys.* 9, 445, 1886; 12, 52, 1867; 16, 143, 1869. *Carbures D'Hydrogene*, 1851-1901 (Collected Works). Anschütz, *Berichte*, 11, 1215, 1878. Lewes, *Trans. Inc. Inst. Gas Eng* 10, 111, 1900. Meyer, *Berichte*, 45, 1609, 1912.

allylene to take part in the synthesis of toluene and xylenes.



From the above assumed mechanism of reaction, part of which is based upon experimental evidence, the formation of benzene and toluene may take place either by—

1. Direct decomposition of methylnaphthalenes.
2. Formation of xylenes and subsequent decomposition.
3. By synthesis from acetylene and allylene.

In all likelihood the three reactions take place in successive steps, or simultaneously.

SUMMARY

1. An oil mainly composed of aliphatic derivatives of naphthalene derived from coal tar was subjected to the following temperature conditions, 600° C., 650° C. and 700° C. and pressures of one, eleven and fourteen atmospheres.

2. Temperature and pressure have a marked effect upon the decomposition of the original oil. Temperature favors decomposition to a greater extent than pressure.

3. The formation of carbon increased with increase of temperature and pressure. Twenty-nine per cent of the original oil went to carbon, at a temperature of 700° C. and fourteen atmospheres. The reaction of decomposition tended toward the ultimate products—gas and carbon.

4. The yield of benzene and toluene increased with temperature in the recovered oil within the limits of these experiments. Toluene formation increased to a maximum and then decreased as the temperature and pressure increased.

5. The maximum condition of 3.2 per cent of benzene formation on basis of original oil used was at 650° C. and fourteen atmospheres pressure. Two per cent of toluene was formed at 600° C. and fourteen atmospheres; and 650° C. and eleven atmospheres.

6. The mechanism of reaction has been assumed to take place, which is partially based upon experimental evidence, forming benzene and toluene—

1. Direct decomposition of methylnaphthalenes.
2. Formation of xylenes and subsequent decomposition.
3. By synthesis of acetylene and allylene.

The three reactions take place either in successive steps or simultaneously.

Department of Inorganic Chemistry,
Columbia University, N. Y.

National Fertilizer Convention

The twenty-third annual convention of the National Fertilizer Association was held at Hot Springs, Va., July 10 to 14. It was a most enthusiastic gathering, despite unfavorable conditions in the fertilizer industry during the past year, due to the cessation of imports. About 250 members were in attendance. The business sessions were held in the mornings, with the afternoons and evenings devoted to golf, riding and other entertainment features. A banquet was held Wednesday evening at which Hon. Theodore E. Burton and ex-Senator Chauncey M. Depew were the speakers. Great interest was shown in the educational work carried on by the Association during the last five years. Horace Bowker, secretary of the American Agricultural Chemical Company was elected president for the coming year; W. D. Huntington, vice-president of the Davison Chemical Company, elected vice-president; Irvin Wuichet re-elected treasurer, and W. G. Sadler re-elected secretary.

Blast Furnace Irregularities and Their Treatment—II

BY J. E. JOHNSON, JR.

Water Troubles

Water troubles are of two separate and distinct kinds, though one kind may, and generally does, lead to the other. These kinds are, first, an interruption either partial or complete in the cooling-water supply of the furnace; second, penetration of the water into the hearth of the furnace. This may be due, in a broad way, either to the failure of one or more cooling members, tuyeres, coolers, cooling plate and the like, or more rarely to the infiltration of water through cracks in the bosh packet or hearth jacket, or into the brick direct where it is not protected by metal jackets.

Failure of the water supply may occur in many ways: Failure of pumping plant, the bursting of the supply main, and as regards the individual cooling members, by the plugging up of the supply cocks with vegetable matter, fish or other foreign substance in the water.

The troubles are of two kinds—partial and complete. The effects of the two cases are very different. If the failure is complete, all the more important cooling members are almost certain to be burnt before the furnace can be cast and stopped. This is a calamity of the first order, and whether the failed members can be restored and the furnace put back into operation after the water supply is restored or must be blown out for repairs, depends upon the conditions of the individual case.

COMPLETE FAILURES OF THE MAIN WATER SUPPLY

These are among the most terrible of the accidents which can take place around the blast furnace, even if the fully supply be restored within a few minutes. The life of the furnace itself depends upon the existence of water cooling, always for the tuyeres, coolers, cinder notch and cinder cooler, and usually for many other cooling members, particularly the cooling plates in the bosh wall, when that type of construction is used. The failure of water on these for more than a second or two is generally sufficient to cause their destruction. The water remaining in them below the drainage level is very often sufficient to cause an explosion when they are burnt, and the small amount drained in from the water system is always enough to chill the furnace to some degree; if there is a small amount of water left flowing in the system, this is sufficient in a few minutes to put the furnace out of business for days.

When the water supply is restored after a brief interruption there are still great difficulties to be overcome. If it is known that any member has failed completely, the only thing to do is to shut the water off from it, but the solution of the problem is not generally as simple as this. It is almost out of the question to shut the water off from an active cooling member like a tuyere when the blast is still on the furnace, because under such conditions the member cut off is burnt out completely in a few minutes, and under the very best conditions the blast blows out through the opening with terribly destructive effect. In most cases this is accompanied by a heavy flow of cinder, and not infrequently by iron with its terrific cutting power, which is likely to lead to the destruction of other cooling members as well as cutting the exterior part of the furnace construction, the columns, hearth and bosh jackets, etc. If the first piece to go is a tuyere, such a sequence leads to the destruction of the cooler also in many instances. If, therefore, a number of cooling parts have failed under such conditions, it is absolutely essential to cast the furnace instantly; then the blast

can be taken off and the water can be shut off from the failed members without danger of serious consequences.

PARTIAL FAILURE OF MAIN SUPPLY

When only partial failure of the main water supply occurs, much can be done to reduce the seriousness of the resulting damage. The furnace must be cast and stopped without regard to any consideration except speed. The blast should be taken off the first instant it is safe to do so without filling the tuyeres with cinder. This does not reduce the temperature of the different zones of the furnace instantly, but it does reduce to zero the velocity of the gas currents, and this is of greater importance in diminishing the destructive power than reduction in temperature itself.

Generally the upper cooling members, particularly those above the mantle, if there are any, lose their water supply first as the head on the system falls. As described under "Construction," if these are made of iron the water circulation can generally be restored to them even after quite a long stoppage, but if they are bronze they generally melt and must either be replaced or else filled up with grout to form a physical support for the lining resting on them and to prevent the gas from burning out through them.

While the loss of these members is extremely serious, its effects are not so immediate or so disastrous as the loss of the cooling members in the hearth and bosh of the furnace. Here the tuyeres and coolers are subjected to the severest conditions by far, and if there be a partial supply of water remaining it should be diverted to them at the expense of all the other cooling members.

I have been through three partial failures of the main water supply, in each case from the failure of a fitting on the line, the breakage of which permitted the escape of the large part of the water supply and the diminution of the head on the system to the point where it was no longer sufficient to supply all the cooling members. In each case we escaped very serious damage by the same general course of procedure. The great difficulty in each case was to restore the broken fitting without shutting off the water supply completely, so causing the failure of all the members even when the furnace was stopped.

There should always be, and generally is, at every plant, a high-pressure water supply of relatively limited volume for fire service and the like, and this we had in each of the three cases mentioned, but in none of them was this supply nearly adequate for the cooling system of the furnace as a whole. In one case the supply was so limited that after the furnace was stopped the tuyeres were pulled out and the noses of the coolers packed with clay. This eliminated the tuyeres from consideration and permitted us to use the scanty supply available for the coolers and the lower rows of cooling plates. These we connected up by hose lines with the high-pressure supply and by driving the latter for all it was worth we were able to force enough water to these members to preserve them under shut-down conditions, though they would not have lasted 10 seconds with the blast on.

While this emergency supply was being connected, everything possible that could be done in advance toward replacing the failed fitting was made ready. Finally, when all was ready, the emergency supply was connected up, the regular supply shut off and the failed fitting removed, the new one was then inserted, the pipe coupled up and the regular supply turned on. In one case things were getting so hot with only the emergency supply that as soon as the new fitting was in place, and before any gasket was inserted in the

joint, we turned on the regular supply for a few minutes in that condition. It made a lively spray from the open joint, but sent enough cool water into the cooling members to give us a few minutes' grace, and in that time we slipped in the gasket and tightened up the bolts and then the regular supply was put on to stay.

It is on account of these experiences that I hold to the belief expressed in the chapter on furnace construction that two separate supply mains should be provided, each connected independently with the circular main around the furnace by a non-return valve set as closely to the circle main as possible. Then in the case of the failure of either main the other will continue to supply the furnace and no difficulty will arise from inability to shut off the break, because it is *between* the valve and the main, as happened in some of these cases.

OBSTRUCTIONS IN PIPES

One of the serious difficulties in a water supply liable to flood conditions is the accumulation of fine twigs, etc., which pass the main screen at the pump intake. These, combined with the silt and mud in the water, make it almost impossible to keep the circulation going on the most exposed cooling parts, especially the tuyeres. Because if the full water supply is diminished even a little, steam is generated and the pressure of this forces the water back into the supply pipe; the discharge then begins kicking and if quick action be not taken the loss of the tuyere is certain to follow within a minute or two, if not within a few seconds.

The best remedy for this difficulty is to have a strainer in the supply line, very much finer than the screen over the main inlet. This must be in duplicate and arranged for quick removal and cleaning; twin strainers are regularly built for this service and some of them are excellent in design and construction. The use of those when supplemented by extra care in times of flood water will cure the worst of the troubles from this source.

In order to guard further against this form of failure, the feed cocks from the circular water main are always made three-way and so arranged that by turning the plug into one position a wire can be run up through the bore of the cock into the supply main and the obstructing particle removed. In cases where this does not suffice to clear the pipe the three-way feature of the cock is useful because by turning it into position to connect the third or spare opening with the supply pipe and connecting a pressure hose onto what is ordinarily the discharge of the cooling member, the water current through that member can be reversed and most obstructions are removed by that treatment.

Certain waters carry in suspension vegetable matters such as the waste of paper mills, and these build up like fish scales in the pipes, in time obstructing them very seriously if not removed. They cannot be flushed out, because like fish scales they lie flat down-stream, but by a strong reversed current they can be ripped off in a few minutes and the pipe entirely cleared.

When the same cooling water is used over and over vegetable growths are apt to occur, much like the green slime seen on stagnant ponds, and these are very troublesome. They can generally be cured by the use of a very small amount of copper sulphate in the water.

EFFECT OF WATER UPON FURNACE OPERATION

In the article on thermal principles of the blast furnace, the subject of moisture in the blast has been treated at some length and the reason for the ruinous effect of water on the operation of the furnace has

been explained. It is well, however, to revert to the subject here and to emphasize its vital importance from the purely operating point of view, as distinguished from what might be considered by some the theoretical.

Let us assume a blast temperature of 1200 deg. and a critical temperature of 2750 deg. Fahr., then referring to our diagram of hearth heat available, it will be seen that the hearth heat per pound of fuel with no moisture is 1845 B.t.u. With $\frac{1}{2}$ lb. of moisture it is 1670 B.t.u., and with 1 lb. of moisture it is 1510 B.t.u. One pound of moisture per 1000 cu. ft. corresponds to 7 grains per cubic foot, and is an amount which is very common in the summer months in almost all climates and may readily be exceeded by 30 or 40 per cent in the South and during July and August in the North. A half-pound is a fair average amount for spring and fall conditions in the greater portion of the iron-producing district.

The difference between these amounts, $\frac{1}{2}$ lb. per 1000 cu. ft., represents the difference between fair average conditions and reasonably good conditions. Now, quantitatively, this corresponds to just about 10 per cent more hearth heat per pound of fuel with the former than with the latter, and this ordinarily corresponds to about 10 per cent greater fuel consumption with the higher quantity of moisture. This is as compared, not with good conditions of three-tenths of a pound, but fair average conditions, on the one hand, while as before stated, the higher quantity taken corresponds only to very fair summer conditions; as between bad summer conditions, say $1\frac{1}{4}$ lb. of moisture, and the good conditions just noted, the difference is between 1750 and 1430 B.t.u. of hearth heat per pound of fuel, a difference of more than 20 per cent, which corresponds very closely to what has been found in practice in many cases.

Taking our rough figure of 10 per cent increase in fuel for $\frac{1}{2}$ lb. per 1000 cu. ft. increase in the moisture in the blast, let us translate this into terms of actual water. On a large furnace blowing, say, 40,000 cu. ft. of air per minute actual, this would correspond to 20 lb. or a little less than $2\frac{1}{2}$ gal. of water per minute, a very small quantity to cause such a vast difference in fuel consumption. This makes it very clear that a heavy leak due to the failure of a cooling member which may discharge into the furnace in a solid stream 20 or 30 gal. a minute will very quickly drown the furnace out, while very small leaks are amply sufficient to upset the delicate equilibrium upon which all successful furnace work depends, for on the basis of the above figures $\frac{1}{2}$ gal. a minute corresponds to a reduction of 1 per cent in the hearth heat, and a change of that amount is usually sufficient to alter the grade of the iron appreciably.

There is one feature about water leaks which may make them even worse than moisture in the blast. The latter is disseminated with absolute uniformity throughout the whole combustion space of the furnace and therefore produces no local irregularity, but when a leak takes place it tends to chill one side of the furnace while the rest goes on undisturbed. This brings about an irregularity which, added to the ruinous effect of the water itself, in whatever form it may be, makes water leakage the worst dreaded enemy of successful furnace operation. I suppose that every furnaceman has had the experience of having a good working furnace begin to work poorly and finally, after endless trouble, finding a small leak in some cooling member, the amount of water passing through which seemed as though it must be absolutely insignificant, and yet when the defective member was replaced by a perfect one the furnace at once returned to its normal condi-

tion and showed every sign that the source of trouble had been removed.

THE LEAKAGE OF WATER INTO THE FURNACE

In striving to maintain the cooling members intact we have to meet conditions perhaps the most severe of any in the operation of the blast furnace. It is absolutely impossible to maintain the furnace without cooling. The water-cooled members must necessarily be very thin or they will burn up in spite of the water cooling, and yet it is absolutely essential that the water must not reach the fire, from whose effects it is protecting the structure. Nothing suffices to maintain these conditions and the satisfactory operation of the furnace which depends upon them, except intelligent construction in the first place, backed up by vigilant and experienced operation.

The inner ends of all the cooling members in the hearth and bosh are in immediate contact with the currents of molten material and gas while the tuyeres are thrust right out into both and are exposed to the constant wear of the coke and to the drip of the iron and cinder running down the bosh walls. These members, therefore, necessarily fail from time to time, either by wear or by being cut by a particularly active jet of iron striking them from above and perhaps in many other ways. These failures lead to the direct flow of water in the hearth.

To determine whether a member has failed or not is one of the most difficult tasks in the operation of the blast furnace, for a tuyere may have a hole $\frac{1}{4}$ in. in diameter burnt in it, through which enough water will flow to chill the furnace in an hour or two, and yet superficial observation does not show the diversion of this water from the regular discharge of the tuyere, so it does not do to shut off these cooling members indiscriminately, because every one so treated is instantly destroyed when the blast is on, and very soon even when the blast is off the furnace. Those so destroyed must be replaced at great expense in money and far greater in loss of time, to say nothing of labor, before the furnace is in shape to go again.

There is no general method of determining whether a certain member is leaking or not if the leak be a small one. The presence of hydrogen in the gas in large quantities can always be detected by watching the combustion at the stoves and boilers, but while this proves the existence of a leak it gives no evidence as to its location, and sometimes the furnaceman will be hunting for days on the suspicion, or perhaps the certainty, that water is going into the furnace, without knowing where it is coming from. In some cases the plan has been adopted of pulling every cooling member in the furnace, not always at one shutdown, but stopping for a half-hour or an hour after every cast and pulling as many as possible, testing these under pressure outside the furnace for leaks and restoring them to place when perfect. This involves an enormous amount of labor, but, as before explained, the destructive action of water on the furnace is so great that a tiny leak is enough to affect the action of the furnace very seriously, and in some cases so destructively that whatever measures are necessary must be used to find it.

Perhaps one of the best methods of determining leaks is to throttle the water supply of the cooling member until the stream from its discharge flows absolutely smoothly, without spatter due to initial velocity, and yet without any break in the stream. By holding a light behind a stream of this kind gas bubbles can generally be seen descending in it if the member is leaking. A necessary feature of this method of test

is to throttle the pressure of the water in the cooling member down below the blast pressure inside the furnace, so that the gas comes in through the leak instead of the water going out.

Another method particularly effective in case of a leaking tuyere is to run a rod in through the peep hole to the nose of the tuyere, leave it for a few minutes and pull it out. In case of anything but a very small leak, the rod is frequently wet on the end.

Very often leaks can be detected by the wetness of the aperture through which the cooling member is inserted. The water is forced back in some rather mysterious way and makes its way out to the outside of the furnace. This is generally an excellent indication, but sometimes the water is so inconsiderate as to travel from the defective cooling member around a half dozen perfect ones and out through the butt of one of the latter, so that it is not safe simply to turn off the water supply from a member which shows wet around the base without investigating further.

There is always a certain amount of gas around the bosh of a furnace, not coming from any particular region that can be discovered, but nevertheless present all around it; the smell of this gas is altered to some extent by the presence of water going into the furnace, and this sometimes serves for a preliminary indication. The master mechanic of a small plant once said: "If you see old Wash (the colored keeper) get up and begin to walk around the furnace with his nose stuck up in the air, you may as well get ready to change a tuyere after cast."

It is impossible to do justice in print to this subject, so vital to the successful operation of the furnace. Nothing but several years of hard knocks around the plant suffices to impart a satisfactory education on the subject.

In order to prevent the difficulties which arise from the entrance of water into the furnace, various efforts have been made to supply a water circulation in which the pressure should be lower than that in the furnace itself, so that any failure would result in a little gas blowing out through the discharge, but not in the entrance of any water into the furnace. One of the schemes which has probably occurred to many is to pull the water through the cooling members by suction rather than driving it through under pressure, but the practical difficulties of maintaining pipe joints tight against vacuum, and the greater complexity necessary in such a procedure, have prevented it from being put into practical use in this country, so far as known to me.

But while there is difficulty in actually sucking the water through the pipes, much may be done to reduce the pressure required to make it flow. The volume desired should be obtained by large pipes under the lowest possible head rather than by smaller pipes under higher pressure. Above all, the discharge pipe should be direct and as free from bends as possible, because the end of this pipe being open, its frictional resistance is the measure of the pressure which must be maintained on the cooling member to produce the required flow. I do not think that enough attention has in all cases been paid to this important detail.

Another matter worthy of attention is the regulation of the water supply of the different members according to their requirements. It is extremely simple to turn them all on full head and run all the water possible through them, but this not improbably takes more heat out of the furnace than is required; it certainly requires an excessive amount of cooling water, and, above all, it maintains an entirely unnecessary pressure upon the cooling member with consequent liability to heavy leakage in case of failure.

In regard to the tuyeres and very often the coolers, the full flow policy is generally desirable, because the conditions to which they are exposed in the furnace are so severe that it is a wonder that any amount of cooling preserves them and we cannot afford to take chances of diminishing their water supply, but for many of the other members, a very much smaller supply of water suffices and they should be throttled down to the point where the water begins to be appreciably warmed in its passage through them, unless this leads to a water supply so small that it is likely to fail accidentally. No member should ever be throttled to this latter degree, because complete stoppage of such a choked water supply is almost sure to take place accidentally sooner or later. In this, as in all matters of furnace operation, there is no substitute for experience and good judgment.

In addition to the penetration of water into the furnace through leaky cooling members, much trouble has arisen in time gone by from water soaking in through the brick work at unprotected points and particularly where the jackets are used, from water entering between the jacket and the brick and thence soaking into the combustion space. It would seem that this action could not occur in view of the pressure of several pounds per square inch existing in the combustion space, but that it does occur most furnacemen know to their sorrow. The explanation probably is that the capillary attraction of the brick is stronger than the blast pressure and so draws the water inward in spite of the pressure outward.

Leaks of this kind can best be prevented by correct design in the first instance. Where steel jackets are used, the greatest care should be taken to see that the upper sheet laps over the lower sheet in every case. The spray trough at the base of the steel bosh jacket, if one is used, should be made amply wide to catch drip and spatter. Where a steel tuyere jacket is used, troughs should be provided above each cooler-opening so that any stray water running down is caught in these troughs and guided down over the side of the coolers away from the furnace. The steel tuyere jacket should have a conical base, riveted water tight to it, to run out over the top of the hearth jacket so as to shed any water which may fall upon it outside the hearth jacket and prevent its running down between the jacket and the brick work. Above all, if any sort of external spray be used on the hearth jacket, the latter should be made as absolutely tight as a high-pressure boiler, otherwise the water will find its way into the brick work and working through this, reach the hearth.

After proper construction of this kind has been provided, continuous watch must be maintained to see that water does not break through the defensive armor of the furnace in some unforeseen way and so make its way into the combustion zone.

Productos de la Ingersoll-Rand is the title of a catalog issued in Spanish by the Ingersoll-Rand Company, 11 Broadway, New York. It is attractively and substantially bound and contains 124 pages replete with illustrations, descriptive matter and tabulated data. The catalog covers completely the company's line of air and gas compressors, vacuum pumps, reciprocating and centrifugal water pumps, rock drilling, metal and coal mining, prospecting and quarrying machinery and pneumatic tools for machine and boiler shop and foundry work. In short this catalog is a complete reference book which should be of great service to Spanish-speaking users of pneumatic machinery.

Flotation Experiments on a Joplin Tailing

BY W. A. WHITAKER, GEORGE BELCHIC, ROY NEAL AND
H. L. VAN VELZER

The Joplin district of Missouri-Kansas is one of the largest regions in this country producing zinc and lead in which flotation has not been generally recognized and adopted, although encouraging signs in this direction have developed within the last few months with the installation of the process by at least one company and with its investigation by two others. During the year 1915, this district produced zinc and lead ores to the value of nearly \$27,000,000.¹

One of the authorities on the district, in commenting on some results obtained in this laboratory has stated² that "if the mill recovery of zinc in the Joplin district, averaging nearly 150,000 tons of metallic zinc for the last four years, could be raised from an average of 60 to 65 per cent to an average of 70 to 75 per cent (the recovery by flotation at Butte is probably about 95 per cent) it would add 25,000 tons of metallic zinc to the output of the district. Moreover, the increased saving would make deposits workable which were too lean to mine profitably before and thus further increase the output of the district." This figure when based on 20-cent spelter would have meant \$10,000,000 added revenue in 1915, and when based on the present prices would add a proportionate amount to the present year's income. It is thus seen that flotation is an economic factor which must be reckoned with by those who are concerned with the future of this district.

However, in studying the possible application of flotation here, there are several economic as well as technical factors which should be carefully considered. It has been recently pointed out³ that most of the mills of the district will average from 100 to 500 tons capacity per day of 10 hours; that the waste material is of two kinds, namely, that resulting from sheet-ground ore and that resulting from soft-ground ore, and under the assumption that 35-mesh material is fine enough for flotation, that "a 100-ton mill treating soft-ground ore will supply enough material to keep a 15-ton flotation unit running" and "a mill treating 200-tons of sheet-ground ore in 10 hours would produce about 10 tons of floatable material, provided most of this material can be collected." These quantities need not be taken, however, as limiting considerations, since the possibility exists of crushing economically some of the coarser material and thus adding to the quantity of possible floatable mineral. Also, future possibilities in the district might include greater capital invested, involving in turn the formation of larger companies, the construction of large mills, and a consequent larger output of tailings. This would mean, of course, still greater justification for flotation.

The object of the investigation herein outlined was to help along the possible application of flotation in the district by determining the behavior of various oils, or mediums, when used on a particular tailing, thereby determining those that give the richest concentrations and the highest extractions. In this work it has not been overlooked that the tailings of the district will vary in character and in zinc content, that the constituents of the various mine waters will vary, and, also, that a combination of oils may produce richer froths than a single oil, and, if not, that such combinations may be more economical to use. Experiments now being carried on will attempt to determine these latter points. However, as a beginning, it was thought ad-

visable to learn the behavior of the single oils on a single tailing before trying on a larger scale the many possible combinations on several tailings, since such data might allow the anticipation of such combinations, besides pointing out other interesting facts. The experiments tabulated in this paper were conducted during the period from Nov. 1, 1915, to March 15, 1916. They constitute a continuation of the flotation investigations begun in this laboratory in 1914 and hitherto published in outline.⁴

Experimental

In studying the behavior of these oils, the tests were run under neutral, acid and alkaline conditions, and with variations in temperature, and in the amount of oil and acid used. Under these conditions the percentage concentration and percentage extraction were determined. The oils used group themselves as follows:

Vegetable products	Drying
	Semi-drying
	Non-drying
Animal products	
Wood distillation products	
Coal distillation products	
Petroleum products	

No attempt was made to include a variety of rare, or unusual oils, which would not be applicable because of their expense. Some of those included, however, will come under the latter objection, but they were used because they represented one of the above groups, and because of certain physical or chemical properties which it seemed desirable to have represented. These properties are grouped for convenience of study in Table I.

One of the most important considerations in successful flotation is the composition of the water in which the process is carried out. The presence of certain colloids, of unusual acidity or unusual hardness may render impossible a process which has been successful on a similar material when a different water supply was used. The introduction of soaps, or of soap forming constituents, such as saponifiable oils and alkali, in order to produce good frothing, may be rendered useless if the mill water contains hardening constituents which will react with the soluble soaps, precipitating them as insoluble soaps and thus obviating the lowering of surface tension with its consequent frothing effect. It seems reasonable to suppose that some of the tests recorded in this paper as carried out in an alkaline pulp, especially those with saponifiable oils, were partly vitiated because of the high Ca and HCO₃ content of the water used. These same tests if carried out in distilled water probably would yield much better results.

It may not be inappropriate to suggest here that if laboratory flotation testing should ever become a standardized procedure the tests will be carried out in distilled water and the necessary corrections, allowances, or modifications needed will be based on the composition of the mill water where it is intended to install the process. Engineers located in city laboratories, far removed from the mining districts, who make a practice of testing various ores for their amenability to flotation are liable to fall into serious error by ignoring this point. Future developments in flotation may reveal the justification for softening, neutralizing or otherwise treating the waters that are used in flotation cells. It may be more economical to treat a water in this way than to add the excess of oil which otherwise may be required, or to sacrifice recovery, by reason of the unusual composition of the water.

The water used in these tests was ordinary tap water

¹Zook, Engineering and Mining Journal, Jan. 8, 1916, p. 65.

²Siebert, Mineral Resources of the U. S., 1914, Part I, p. 885.

³C. A. Wright, Possibilities of Flotation for Lead and Zinc Ores in the Joplin District. Bureau of Mines (Multigraph Paper).

⁴The Flotation of Joplin-Galena Slimes. This journal, Nov. 1, 1915.

TABLE I—PROPERTIES OF OILS

Kind of Oil	Specific Gravity at 20° C.	Viscosity at 25° C. (Engler Viscosity)	Surface Tension (Capillary method)	Saponification Value	Chief Constituents of the Oil
Castor Oil	0.936	139.00	43.50	176 - 183	Ricinolein and its isomers. Small amounts of stearin.
Corn Oil	0.925	10.40	30.60	186 - 193	Palmitic, stearic, arachidic, linolic, and oleic glycerides. Small amounts of acetic and formic acids.
Cottonseed Oil	0.924	9.70	29.50	191 - 198	Olein, linolein, palmitin, and stearin.
Linseed Oil	0.935	6.25	34.50	186 - 192	Palmitin, stearin, and myristin. Oleic, linolic and linolenic acids. Small amounts of unsaponifiable matter.
Oleic Acid	0.902	7.90	23.70	190	About 94% free fatty acid—oleic, and 3% unsaponifiable matter.
Olive Oil	0.913	11.50	35.20	189 - 196	Olein, linolein, and palmitin.
Rape Seed Oil	0.915	11.70	29.80	171 - 179	Stearin, rapin, erucin and 0.41 - 1.43 % arachidic acid.
Sunflower Oil	0.922	8.65	29.50	186 - 194	Linolic and oleic glycerides.
Tung Oil (China Wood)	0.938	39.00	39.00	190 - 196	Olein and 75% elaeomargarin; 10% oleic and 2-3% saturated acids.
Fish Oil	0.935	7.00	35.00	197 - 203	Glycerides of liquid and solid acids; valerianic acid and some sperm oil.
Eucalyptus Globulus	0.850	1.37	24.20	—	6% aldehydes (butyric, isovaleric, and capronic); 21% pinene; 47% cineol; 25% alcohols. Small amount of camphene.
Oil of Hemlock	0.870	1.15	30.00	—	Pinene, cadinene, bornyl acetate, and camphene.
Wood Distillate	0.931	1.11	30.10	—	Methyl alcohol, acetic acid, acetones, hydrocarbons, and tarry products.
Crude Wood Turpentine Oil #75	0.869	1.12	30.50	—	Terpined, pinene, resin, formic and acetic acids. Small amounts of camphene, dipentene, and traces of aldehydes.
Refined Wood Creosote Oil #200	0.974	1.50	28.00	—	Cresol, phenol, creosol, and guaiacol.
Crude Wood Oil #300	1.006	5.21	22.60	—	Light rosin oils, light tar oils, creosol, phenol, benzol, pinene, and dipentene.
Pure Pine Oil #5	0.995	2.25	23.30	—	Laevo-menthone, limonene, and some of the higher boiling terpenes.
Pine Tar Creosote Oil #7	1.020	1.37	28.00	—	Methyl ethers of catechol and its homologues; phenol, cresol, dimethyl pyrogallate, pitch, and other hydrocarbons.
Special Pine Tar Creosote Oil #8	1.036	8.25	24.20	—	Phenol, cresol, dimethyl pyrogallate, and methyl ethers of catechol and its homologues.
Wood Creosote Oil #11	0.973	1.39	37.60	—	Cresol, phenol, creosol, and pitch.
"Tarco" (Coal Tar Oil)	1.056	7.41	31.20	—	Coal tar derivatives containing phenol, cresol, naphthalene, toluene, anthracene, pyridine, and quinoline.
"Creco" (Coal Tar Oil)	0.960	2.12	29.60	—	Phenol, toluol and homologues.
Coal Tar Creosote with Carbolic Acid #26	0.976	1.21	28.00	—	Cresol, phenol, creosol, naphthalene, phenantrene, and pyridine.
Crude Carbolic Acid	1.027	1.93	30.60	—	Phenol, cresol and homologues.
Crude Petroleum (Kansas)	0.844	1.81	32.30	—	Mixture of hydrocarbons of various series together with a small percentage of nitrogenous basic matter, oxygenated bodies, and organic compounds with sulphur.
Paraffin Oil	0.876	4.50	30.10	—	Mixture of hydrocarbons of the paraffin series, obtained by purifying and decolorizing the fraction boiling above 300°C. obtained in the distillation of crude oil.
Sludge (insoluble in water)	0.918	3.50	29.70	—	Mixture of compounds that are removed with the sulphuric acid in the acid treatment of the various distillation products from crude petroleum, chiefly aromatic hydrocarbons, tarry products, and sulphonic compounds.
Sludge (soluble in water) #	1.020	1.10	28.20	—	A special preparation of sludge.

* Diluted - 3 parts of water to 1 part of sludge.

1. Pensacola Tar and Turpentine Co., Gulf Point, Florida.

2. General Naval Stores Co., 175 Front St., New York.

3. American Coal Refining Co., Denver, Colorado.

4. Sludge from which most of the sulphuric acid has been removed - Standard Oil Co., Indiana.

1916

from the city mains and is represented by the analysis^a given in Table 3.

TABLE III—ANALYSIS OF LAWRENCE WATER

	P.P.M.
SiO ₂	37.4
Fe ₂ O ₃ +Al ₂ O ₃	14
Ca.....	125.9
Mg.....	18.4
Na+K.....	37
Cl.....	36
SO ₄	71.6
HCO ₃	429

For comparison the analysis of Table 4 of waters from the Joplin district are included.^b

TABLE IV—MISSOURI LEAD & ZINC CO., WELLS, JOPLIN ANALYSTS, CLEVELAND & MILLER

Depth.....	1387 ft.	940 ft.
Reacting values.....	P.P.M.	P.P.M.
Na.....	1.007	9836
Ca.....	1.844	2.196
Mg.....	1.405	1.781
SO ₄.....	.2989	.2994
Cl.....	.3374	.2814
CO ₂	3.620	4.380
H ₂ S.....	Present	
Total weight dissolved solids.....	336	396

Winslow Mine Water
Webb City
Analyst, V. H. Gottschalk

Chico Spring
Galena
Analysts, E. H. S. Bailey, E. McCa-
lum

REACTING VALUES			
	P.P.M.		P.P.M.
Na.....	.2065	Na.....	.1479
K.....	.07855	Ca.....	2.285
Ca.....	4.037	Mg.....	.5590
SO ₄	1.229	Zn.....	Trace
Cl.....	.05358	SO ₄	1.353
CO ₂	3.039	Cl.....	.0987
		CO ₂	1.54
Total weight dissolved solids.....	350	Total weight dissolved solids.....	243

It seems reasonable to suppose that the possible presence in any of the Joplin waters of acids, salts of calcium and of other metals, should not interfere with successful flotation, since many of the results tabulated here were successful in the presence of a relatively high acid and calcium content.

The tailing used in these tests is much finer than the average material for the district. It was taken from a pond in Galena and is described by the screen and chemical analyses given in Table 5.

TABLE V—SCREEN ANALYSIS

	Mesh	Weight, Grams	Per Cent	Per Cent Cumulative	Per Cent Zinc
All pass.....	80				
Retained on.....	100	5.0	1.02	1.02	1.24
Retained on.....	150	4.0	.81	1.83	1.91
Retained on.....	200	10.0	2.04	3.87	3.26
Through.....	200	472.0	96.13		3.65
Totals.....		491.0	100.00		

CHEMICAL ANALYSIS

	Per Cent
Zinc.....	3.60
Lead.....	.31
Iron.....	.53
Insoluble.....	91.72

The machine used was a small laboratory size of the mechanically agitated type. Lyster or Hoover design, and consisted of an agitating compartment and a floating compartment.

Method of testing: To the agitating compartment of the machine were added:

2000 grams of water

400 grams of tailing

varying amounts of oil (See Table I).

The mixture was agitated for 2 minutes with a

propeller speed of 1800 r.p.m. and for the following 5 minutes agitation was continued, with the door separating the two compartments, opened, so as to allow the froth to form and gather in the flotation compartment. The collected froth in the flotation compartment was removed by skimming and overflow, after a total of 7 minutes agitation, and was dried, weighed and assayed for zinc content. The machine was cleaned of gangue, and a fresh charge added.

Discussion

The following discussion is based upon the results tabulated in Table II. The term "neutral pulps" refers to pulps in which neither acid nor alkali has been used; by "low acid pulps" is meant pulps to which 4 lb. of concentrated sulphuric acid have been added per ton of dry tailing; by "high acid pulps" is meant pulps to which 8 lb. of concentrated sulphuric have been added per ton of dry tailing, and by "alkaline pulps" is meant pulps to which 8 lb. of sodium hydroxide have been added per ton of dry tailing.

Castor.—The highest concentrated was 47.5 per cent, produced by using 4 lb. of oil per ton of tailing in the low acid pulps. Increasing the amount of oil did not produce a richer froth in this acid condition, nor in the high acid pulps, nor in the neutral pulps. The same quantity of oil used in the alkaline pulp produced a very lean froth. Castor possesses the highest viscosity of any of the oils used. Extraction increased with increasing quantities of oil reaching a high point, 73.4 per cent, with 12 lb. in a neutral pulp.

Corn.—With this oil the richest froth, 47 per cent, was obtained under the same conditions as in the case of castor oil, 4 lb. of oil in the low acid pulp. Here, also, increasing the oil did not produce richer froths under any of the conditions tried. Extraction increased with increasing quantities of oil, reaching 55.43 per cent in a neutral pulp, and 77.50 per cent in an alkaline pulp.

Cottonseed.—The richest froths produced by this oil were obtained in a more acid pulp than in the preceding cases. Two (2) lb. of oil in the high acid pulp gave a 51.1 per cent froth. Increasing the oil did not increase concentration save in a very slight degree, where 8 lb. were used. Extraction increased with increasing oil reaching a maximum at 48 per cent.

Linseed.—In the case of linseed, also, the richest froths were produced in the high acid pulps reaching the highest concentration, 55.71 per cent with 6 lb. of oil. A lesser amount of oil, 4 lb., produced approximately as rich a froth. However, with this oil, extractions were higher in the low acid pulps. Linseed was used because it is a typical drying oil and because of its tendency to partially oxidize when subjected to extreme aeration, as would be the case in flotation, and become more viscous. Cotton-seed, rape seed and certain other oils behave similarly but to a lesser degree. It is interesting to note in this connection that the concentrate produced by linseed was the richest obtained in this series of more than 270 tests.

If it were possible to have a froth consisting only of water, air, oil and zinc sulphide, and with no gangue present, this froth when "broken" and dried should assay 67.1 per cent zinc, that is, the theoretical per cent of zinc is ZnS. The above concentrate which ran 55.71 per cent zinc is, therefore, an unusual case of mineral selectivity, and especially so, when we consider the zinc assay of the original tailing, namely 3.6 per cent. It represents a concentration of 1 to 15 plus.

Oleic Acid.—Lean froths were obtained with this medium, the best being a 34.1 per cent concentrate with

^aHaskins & Young, Water Supplies of Kansas, Eng. Bul. No. 5, Univ. of Kansas.

^bSiebert, Origin of the Zinc and Lead Deposits of the Joplin Region, Bul. 606, U. S. G. S.

TABLE II—RESULTS

Kind of Oil	Condi- tion of pulp	Temperature of Pulp 20° C.				Condi- tion of pulp	Temperature of Pulp 20° C.				Condi- tion of pulp	Temperature of Pulp 70° C.			
		Amount of oil used per ton of ore pounds	Assay of con- centrates per cent	Assay of con- centrates per cent zinc	per cent extraction		Amount of oil used per ton of ore pounds	Assay of con- centrates per cent	Assay of con- centrates per cent zinc	per cent extraction		Amount of oil used per ton of ore pounds	Assay of con- centrates per cent	Assay of con- centrates per cent zinc	per cent extraction
Castor Oil	neutral	6.0	0.3	42.15	27.00	acid (1.50) 4 pounds to ton ore	4.0	0.2	47.51	25.50	acid (1.50) 4 pounds to ton ore	6.0	0.3	36.94	33.10
		8.0	0.4	42.50	54.00		6.0	0.3	44.97	44.30		8.0	0.4	40.18	29.00
		12.0	0.6	43.09	73.40		8.0	0.4	37.80	40.70		12.0	0.6	42.87	60.00
Corn Oil	"	4.0	0.2	36.37	22.70	"	4.0	0.2	47.00	32.64	"	4.0	0.2	36.82	25.00
		8.0	0.4	43.40	51.00		8.0	0.4	44.41	33.92		8.0	0.4	47.00	43.00
		12.0	0.6	40.00	55.43		12.0	0.6	37.50	38.00		12.0	0.6	45.40	42.00
Cottonseed Oil	"	2.0	0.1	28.80	14.00	"	2.0	0.1	no fresh formed	—	"	2.0	0.1	51.10	18.00
		4.0	0.2	38.80	32.30		4.0	0.2	43.70	27.00		4.0	0.2	51.00	46.00
		6.0	0.3	36.50	43.10		6.0	0.4	42.00	35.00		6.0	0.4	52.70	48.00
Linseed Oil	"	4.0	0.2	40.66	49.20	"	6.0	0.3	42.30	66.00	"	4.0	0.2	54.81	40.00
		6.0	0.3	38.48	58.70		8.0	0.4	43.71	64.70		6.0	0.3	55.71	48.00
		8.0	0.4	37.87	63.50		12.0	0.6	37.29	68.30		8.0	0.4	55.11	52.00
Oleic Acid	"	2.0	0.1	6.54	4.00	"	2.0	0.1	9.20	14.00	"	12.0	0.6	38.00	42.10
		4.0	0.2	6.65	13.00		4.0	0.2	34.10	9.40		20.0	1.0	14.50	42.50
		8.0	0.4	5.61	49.00		—	—	—	—		—	—	—	—
Olive Oil	"	8.0	0.4	16.45	7.00	"	8.0	0.4	36.03	27.90	"	8.0	0.4	15.65	20.60
		12.0	0.6	12.70	3.50		12.0	0.6	41.47	40.32		12.0	0.6	20.19	23.83
		20.0	1.0	24.00	28.40		20.0	1.0	39.25	46.30		20.0	1.0	41.46	46.10
Peanut Seed Oil	"	4.0	0.2	16.18	10.10	"	8.0	0.4	23.21	18.00	"	4.0	0.2	45.00	22.00
		8.0	0.4	26.21	20.00		12.0	0.6	43.87	36.70		8.0	0.4	39.12	23.00
		12.0	0.6	25.80	10.70		20.0	1.0	35.62	55.00		12.0	0.6	43.70	63.30
Sunflower Oil	"	4.0	0.2	14.20	6.00	"	4.0	0.2	10.30	6.00	"	4.0	0.2	43.80	13.00
		8.0	0.4	17.70	8.80		8.0	0.4	21.00	14.00		8.0	0.4	48.30	30.20
		12.0	0.6	12.75	11.50		12.0	0.6	19.75	25.00		12.0	0.6	53.20	46.00
Tung Oil (China Wood)	"	4.0	0.2	no fresh formed	—	"	4.0	0.2	no fresh formed	—	"	4.0	0.2	no fresh formed	—
		12.0	0.6	—	—		12.0	0.6	16.48	8.00		8.0	0.4	—	—
		20.0	1.0	12.34	17.10		20.0	1.0	27.73	27.00		12.0	0.6	—	—
Fish Oil	"	4.0	0.2	13.70	8.70	"	4.0	0.2	36.00	5.00	"	4.0	0.2	—	—
		8.0	0.4	6.05	7.00		8.0	0.4	11.50	3.20		8.0	0.4	—	—
		12.0	0.6	10.94	21.20		12.0	0.6	20.00	27.40		12.0	0.6	—	—
Eucalyptus Globulus	"	1.0	0.05	22.36	19.00	"	1.0	0.05	21.37	19.30	"	1.0	0.05	27.00	75.00
		2.0	0.10	39.13	51.60		2.0	0.10	22.72	28.40		2.0	0.10	28.00	87.00
		4.0	0.20	50.00	25.00		4.0	0.20	25.15	31.30		4.0	0.20	29.30	98.00
Oil of Hemlock	"	1.0	0.05	45.23	38.00	"	1.0	0.05	46.30	32.10	"	1.0	0.05	no fresh formed	—
		2.0	0.10	31.78	75.00		2.0	0.10	43.85	61.00		2.0	0.10	39.45	27.40
		4.0	0.20	26.62	76.00		4.0	0.20	34.12	83.00		4.0	0.20	38.40	18.00
Wood Distillate	"	2.0	0.1	25.00	27.20	"	2.0	0.10	23.00	39.20	"	2.0	0.10	19.30	16.10
		6.0	0.3	20.10	39.00		4.0	0.20	21.30	48.00		4.0	0.20	26.80	24.20
		12.0	0.6	16.20	41.10		6.0	0.30	37.40	45.30		8.0	0.40	27.25	30.00
Crude Wood Turpentine Oil	"	1.0	0.05	22.70	40.50	"	0.5	0.025	28.47	17.80	"	0.5	0.025	10.00	13.20
		2.0	0.10	21.89	71.50		1.0	0.050	39.60	30.20		1.0	0.050	18.00	16.20
		4.0	0.20	18.51	71.20		2.0	0.100	31.00	80.60		2.0	0.100	12.80	25.00
Refined Wood Creosote Oil	"	0.5	0.025	16.51	10.32	"	0.5	0.025	24.47	19.00	"	0.5	0.025	37.90	17.50
		1.0	0.050	23.52	55.50		1.0	0.050	32.12	39.40		1.0	0.050	21.20	45.00
		2.0	0.100	9.60	96.00		2.0	0.100	24.00	81.40		2.0	0.100	15.00	83.20
Crude Wood Oil	"	0.5	0.025	16.21	11.20	"	0.5	0.025	14.05	10.70	"	0.5	0.025	22.70	12.60
		1.0	0.050	22.51	32.80		1.0	0.050	30.00	29.30		2.0	0.10	21.00	17.30
		2.0	0.100	7.90	74.00		2.0	0.100	17.94	42.40		4.0	0.20	22.00	20.00
Pure Pine Oil	"	1.0	0.05	42.70	44.40	"	1.0	0.05	36.23	55.40	"	2.0	0.1	53.20	43.80
		2.0	0.10	45.40	72.50		2.0	0.10	31.22	54.20		4.0	0.2	43.10	71.40
		4.0	0.20	43.00	60.00		4.0	0.20	38.10	55.50		6.0	0.3	42.40	74.00
Pine Tar Creosote Oil	"	1.0	0.05	26.00	8.60	"	2.0	0.1	22.20	64.00	"	2.0	0.1	9.24	51.00
		2.0	0.10	17.70	54.00		4.0	0.2	16.00	70.00		4.0	0.2	8.68	59.00
		4.0	0.20	10.40	70.20		—	—	—	—		—	—	—	—
Special Pine Tar Creosote Oil	"	0.5	0.025	16.47	16.00	"	0.5	0.025	19.53	16.40	"	0.5	0.025	23.14	17.60
		1.0	0.050	21.00	20.40		1.0	0.050	24.61	38.40		1.0	0.050	21.40	13.30
		2.0	0.100	8.51	67.60		2.0	0.100	12.19	55.00		2.0	0.100	24.20	16.20
Wood Creosote Oil	"	2.0	0.1	18.40	23.30	"	2.0	0.1	21.15	40.00	"	2.0	0.1	23.00	68.20
		4.0	0.2	15.50	59.00		4.0	0.2	14.00	61.00		4.0	0.2	13.00	64.30
		8.0	0.4	15.00	61.00		—	—	—	—		—	—	—	—
"Tarco" (Coal Tar Oil)	"	0.5	0.025	24.00	23.30	"	0.5	0.025	32.00	32.10	"	0.5	0.025	27.40	11.40
		1.0	0.050	32.00	60.00		1.0	0.050	35.60	47.00		1.0	0.050	16.40	6.80
		2.0	0.100	16.00	88.50		2.0	0.100	32.00	67.00		2.0	0.100	28.00	9.60
"Greco" (Coal Tar Oil)	"	1.0	0.05	26.00	12.60	"	1.0	0.05	32.00	24.30	"	1.0	0.05	20.60	7.00
		2.0	0.10	28.00	53.20		2.0	0.10	33.00	64.10		2.0	0.10	17.00	7.10
		3.0	0.15	21.00	71.30		3.0	0.15	22.10	80.00		3.0	0.15	30.00	23.00
Coal Tar Creosote with Carbolic Acid	"	4.0	0.2	33.00	23.10	"	2.0	0.1	20.00	19.00	"	2.0	0.1	25.20	12.20
		8.0	0.4	39.00	53.40		4.0	0.2	14.00	24.00		4.0	0.2	23.80	10.00
		12.0	0.6	30.00	83.30		8.0	0.4	13.00	46.00		8.0	0.4	34.00	24.00
Crude Carbolic Acid	"	0.5	0.025	23.81	24.80	"	0.5	0.025	29.38	43.00	"	0.5	0.025	21.00	34.20
		1.0	0.050	20.90	42.10		1.0	0.050	27.60	47.00		1.0	0.050	30.55	27.60
		2.0	0.100	25.10	40.00		2.0	0.100	26.60	46.10		2.0	0.100	24.63	21.00
Crude Petroleum (Kerosene)	"	4.0	0.2	17.63	8.60	"	4.0	0.2	9.20	18.10	"	4.0	0.2	no fresh formed	—
		8.0	0.4	35.60	27.60		12.0	0.6	9.78	48.00		12.0	0.6	11.31	4.30
		12.0	0.6	11.44	5.40		20.0	1.0	6.10	40.00		20.0	1.0	6.20	5.10
Paraffin Oil	"	8.0	0.4	no fresh formed	—	"	8.0	0.4	no fresh formed	—	"	8.0	0.4	no fresh formed	—
		12.0	0.6	—	—		12.0	0.6	—	—		12.0	0.6	—	—
		20.0	1.0	—	—		20.0	1.0	—	—		20.0	1.0	25.97	21.20
Sludge (Insol- uble in water)	"	2.0	0.10	16.80	16.30	"	2.0	0.10	28.06	12.60	"	—	—	—	—
		3.0	0.15	38.70	41.10		3.0	0.15	28.15	42.40		—	—	—	—
		4.0	0.20	27.40	61.00		4.0	0.20	34.00	66.10		—	—	—	—
Sludge (Sol- uble in water)	"	2.0	0.10	13.14	21.00	"	1.0	0.05	14.52	10.00	"	—	—	—	—
		3.0	0.15	7.36	10.00		2.0	0.10	14.09	9.20		—	—	—	—
		4.0	0.20	23.17	21.10		4.0	0.20	18.12	10.40		—	—	—	—

1. Pensacola Tar and Turpentine Co., Gulf Point, Florida.

2. General Naval Stores Co. 175 Front St., New York, which most of the sulphuric acid has

OF TESTS

Temperature of Pulp 20°C.					Remarks.
Condition of pulp	Amount of oil used per ton of ore	Assay of concentrates	percent extraction		
Neutral pulp	not tested	—	—	—	In neutral pulp the froth formed is a thin sheet with the absence of air bubbles; acid and high temperature forms brittle, bubble froths, alkali added to the pulp forms a permanent froth.
"	4.0	0.2	19.80	23.30	
"	2.00	1.0	28.30	71.50	In neutral and acid pulps at low temperature bubble froths form almost instantly but these are of short duration, high temperature produces selective froths, alkali tends to form a frozen froth.
"	2.0	0.1	43.80	46.00	In neutral and acid pulp at low temperatures brittle bubble froths form. High temperature produces selective action and alkali added to the pulp is beneficial.
"	4.0	0.2	18.24	17.00	In neutral and acid pulps at low temperatures partial bubble froths form. High temperature tends to make a more permanent froth, while alkali is not beneficial.
"	2.0	0.1	6.44	7.10	In neutral and acid pulps, viscous, frozen froth forms. High temperature has no apparent effect upon the frothing properties of the oil. Alkali tends to increase the collecting power of the froth.
"	4.0	0.2	3.37	36.30	
"	8.0	0.4	7.60	41.00	In neutral pulp the froth takes the appearance of a scum or thin sheet. Acid is beneficial, while high temperature makes the froth brittle. Alkali tends to make a frozen froth.
"	2.00	1.0	16.28	46.40	In neutral and acid pulps at low temperature brittle bubble froths form, when large quantities of oil are used. High temperature increases the selective action of the froth.
"	4.0	0.2	26.30	18.20	In neutral and acid pulp a thin sheet or scum-like froth forms. High temperature tends to form a bubble froth, while alkali forms a viscous frozen froth.
"	2.00	1.0	21.56	33.00	When small quantities of oil are used there is scarcely any tendency to form a froth. High temperature is detrimental; but alkali tends to make a viscous froth.
"	4.0	0.2	31.00	28.00	In neutral and acid pulps at low temperature froths of the bubble type form, but in small amounts, high temperature destroys the froth, and alkali is beneficial in that it tends to form a fairly persistent froth.
"	2.0	0.1	27.70	71.00	In neutral and acid froths at low temperature thin and brittle froths form. High temperature creates a more permanent froth while alkali tends to form a viscous, frozen froth.
"	2.0	0.1	23.00	80.00	In neutral and acid pulps at low temperature good froths form. High temperature tends to rupture the froth, while alkali forms a viscous, frozen froth.
"	2.0	0.1	24.04	78.50	In neutral and acid pulps at low temperature good froths form. High temperature tends to rupture the froth. Alkali tends to form a viscous, frozen froth.
"	1.0	0.05	28.10	66.30	In neutral, acid, or alkaline pulps this oil will form viscous frozen froths showing poor selective action.
"	1.0	0.05	21.00	54.00	When used in large quantities this oil forms viscous froths which carry the gangue minerals as readily as the sulphides.
"	1.0	0.05	24.40	34.00	In acid, alkaline or neutral pulps the froth formed is viscous and frozen, showing poor selective action.
"	2.0	0.1	13.00	80.00	In neutral and acid pulps the froth forms almost instantly, showing good selective action. High temperature tends to make for better selective action of the froth. Alkali increases the frothing action but decreases the selective action.
"	2.0	0.1	12.00	60.00	In neutral, acid and alkaline pulps, this oil produces viscous froths that carry the gangue as readily as the sulphide minerals. High temperature has the tendency of further increasing the collecting power of the froth.
"	1.0	0.05	21.21	84.00	In neutral, acid, and alkaline pulps at low temperature good froths form, poor in selective action. High temperature tends to rupture the froth.
"	2.0	0.1	23.18	68.00	In neutral, acid and alkaline pulps, this oil produces viscous froths showing poor selective action. Temperature has but little effect upon the frothing properties of the oil.
"	1.0	0.05	47.00	50.00	In neutral and acid pulps at low temperature, large viscous froths form. High temperature and a large quantity of acid is detrimental, alkali tends to produce a good selective froth.
"	1.0	0.05	37.40	42.00	This oil appears to behave in all respects like "Tarco"
"	4.0	0.2	36.20	45.20	In neutral and acid pulps this oil acts both as a frother and collector forming frozen froths. High temperature is detrimental in that it tends to rupture the froth. Alkali is beneficial.
"	0.5	0.025	16.60	15.00	In neutral and acid pulps brittle bubble froths form. High temperature weakens the froth and alkali is in part detrimental.
"	4.0	0.2	36.40	45.50	With a large quantity of oil and pulp neutral there is a tendency for the production of good froths. Acid is detrimental while alkali produces viscous, frozen froth with good selective action.
"	no froth formed	not tested	—	—	The oil rises to the surface of the floating compartment without any tendency to form a bubble froth or even a scum froth.
"	not tested	—	—	—	This oil is a good frother and collector and forms a viscous, frozen froth. Acid is beneficial.
"	not tested	—	—	—	This oil is a good collector but shows poor selective action. In its frothing properties this oil resembles soaps, or the action of alkali with many of the oils.

3. American Coal Refining Co., Denver, Colorado.
 4. Sludge from
 removed—Standard Oil Co., Indiana.

4 lb. of oleic in the low acid pulp. Extraction reached a maximum at 49 per cent in a neutral pulp.

Olive. — The best concentration here, 41.47 per cent, was obtained in the low acid pulp, using 12 lb. of the oil. The best extractions were obtained in the same pulps. Froths obtained in neutral pulps were lean.

Rape Seed. — A high acid pulp gave the richest froth with this oil, the same condition which produced the richest froths with linseed and cotton-seed oils. Four (4) lb. of oil in the warm high acid pulp gave a 45 per cent froth. Neutral pulps gave lean froths. Extractions were highest in the high acid pulps.

Sunflower. — Here, also, the high acid pulps gave the richest concentrates, 43 to 53 per cent, and the highest extractions. Other conditions produced noticeably poorer results. Extraction increased with increasing amounts of oil.

Tung. — This oil gave poor results and, in many cases, no froth was formed. A large quantity of oil, 20 lb., yielded a froth of 27.73 per cent and an extraction of 21 per cent in a low acid pulp. In the alkaline pulp, concentration was slightly less and extraction was slightly higher than in the low acid pulp.

Fish. — With this oil in the low acid pulp, a 36 per cent froth, the maximum, was obtained, but this was accompanied by a very low extraction, 5 per cent. In an alkaline pulp, concentration was slightly less, but the extraction was 28 per cent.

Eucalyptus. — Here the best concen-

trations took place in a neutral pulp with small amounts of oils. The richest froth obtained, 39.13 per cent, was produced by 2 lb. of oil. In the high acid pulps extractions were unusually high, reaching a maximum at 98 per cent with 4 lb. of oil.

Hemlock.—Good concentrations were effected in both neutral and low acid pulps by using only 1 lb. of oil. Increasing the oil did not improve these results though extractions increased as usual, reaching a maximum at 83 per cent.

Wood Distillate.—Concentration was highest here in the low acid pulp, reaching 37.4 per cent with 6 lb. of the medium. As before, extractions generally increased with increasing oil. However, an alkaline pulp with 2 lb. of oil gave a higher extraction, 78.50 per cent, than did the neutral and acid pulps which contained greater quantities of oil.

Crude Wood Turpentine, No. 75.—The highest concentration was a 39.60 per cent froth obtained with the use of 1 lb. of this material in a low acid pulp. The highest extraction, 80.60 per cent, was obtained in the same pulp when 2 lb. of material were used.

Refined Wood Creosote, No. 200.—The tests with this medium show relatively high extractions accompanied by low selectivity for the mineral. In a neutral pulp extraction ran to 96 per cent, but this was accompanied by a very lean froth, 9.6 per cent. The best froth, 32.12 per cent, was obtained in a low acid pulp with 1 lb. of the medium.

Crude Wood, No. 500.—The best results with this medium were obtained under the same conditions as in the preceding case, namely, the richest froth, 30 per cent, resulted from 1 lb. of the medium in a low acid pulp and the highest extraction, 74 per cent, from 2 lb. of the medium in a neutral pulp. In an alkaline pulp, 1 lb. caused an extraction of 54 per cent with a froth of 21 per cent.

Pure Pine, No. 5.—Pine oil produced good froths in neutral and in high acid pulps, reaching the maximum concentration, 53.2 per cent, with 2 lb. of oil in the high acid pulp. Low acid pulps do not concentrate so well with this oil. Extraction was highest, 80 per cent, in the alkaline pulp.

Pine Tar Creosote, No. 7.—Lean froths, with moderately good extractions, characterized this medium. A neutral pulp with 1 lb. of the medium produced a richer froth, 26 per cent, than any of the other conditions tried.

Special Pine Tar Creosote, No. 8.—A low acid pulp produced the richest froth, 34.61 per cent, with 1 lb. of this medium. Extractions increased with increasing amounts of the creosote when in neutral and acid pulps, but in an alkaline pulp, with only 1 lb. of creosote, it was higher, 84 per cent, than under any other condition.

Wood Creosote, No. 17.—Low concentrations with some good extractions characterized this medium. The best concentrate, 23 per cent, and the best extraction, 88.2 per cent, were obtained in a high acid pulp with 2 lb. of oil.

Tarco.—This medium was one of two of those tried that gave a higher froth, 47 per cent, in an alkaline pulp than in either neutral or acid pulps. The next richest froth, 35.6 per cent, was produced with 1 lb. of Tarco in a low acid pulp. A high extraction, 88.5 per cent, resulted with 2 lb. of tarco in a neutral pulp.

Creco.—This material seemed to act in the same manner as tarco, but to a lesser degree. Here, again, the richest froth under the conditions tried, 37.4 per cent, was produced in an alkaline pulp. Also, the next richest froth, 33 per cent, was produced in the low acid pulp with 2 lb. of creco. Maximum extraction reached 80 per cent with 3 lb. in the low acid pulp.

Coal Tar Creosote with Carbolite, No. 22.—This medium produced the maximum concentration, 43 per cent, in a low acid pulp when 8 lb. was used. The same quantity of medium gave a 39 per cent froth in a neutral pulp. With an increasing quantity in a neutral pulp extraction reached 83.3 per cent. In an alkaline pulp, concentration was more effective per pound of medium used, 4 lb. yielding a froth of 36.2 per cent, which was a higher yield than that produced by an equal quantity under neutral or acid conditions.

Crude Carbolite Acid.—The maximum concentration, 41.03 per cent, was produced in the high acid pulp using only $\frac{1}{2}$ lb. of the medium. Judging the comparative froths obtained in all tests by the weight of the oil or medium used, this froth obtained with the use of $\frac{1}{2}$ lb. of crude carbolite per ton, was the most effective result of all those tabulated. Extraction reached a maximum at 47 per cent with 1 lb. in the low acid pulp.

Crude Petroleum.—Concentration was here highest in the alkaline pulp with a froth of 36.4 per cent 4 lb. Froths obtained in acid pulps were lean. In a neutral pulp 8 lb. of this medium yielded a froth of 35.6 per cent. In low acid pulps, extractions were fair when large quantities of oil were used.

Paraffin Oil.—The peculiar behavior of this oil in its non-frothing property confirms a statement recently made¹ that an oil must contain suitable colloidal matter in suspension in order to produce a froth. By reason of the treatment to which this oil has been subjected in order to render it colorless, odorless and tasteless, it is assumed that all colloidal matter has been removed from it.

Sludge (insoluble).—This material was tested under two conditions only, in neutral and low acid pulps. The froths obtained in the low acid pulps were slightly richer than those obtained in the neutral pulps. Extraction reached 66 per cent.

Sludge (soluble).—This soluble material was not so effective in concentration or extraction as the insoluble sludge, all results being uniformly low.

TABLE VI—HIGHEST CONCENTRATIONS IN NEUTRAL PULPS

Medium	Pounds per Ton of Ore	Per Cent Zinc in Concentrates
Pure Pine No. 5.	2	45.40
Hemlock	1	45.23
Corn	8	43.40
Castor	12	43.00
Linseed	4	40.66
Eucalyptus	2	39.13
Coal tar creosote and carbolite No. 22	8	39.
Cotton seed	4	38.8
Sludge (insol.)	3	35.7
Crude petroleum	8	35.6
Tarco	1	32.
Crude turpentine No. 75	1	30.70
Creco	2	28.
Rape seed	8	26.21

TABLE VII—HIGHEST EXTRACTIONS IN NEUTRAL PULPS

Medium	Pounds per Ton of Ore	Per Cent Extraction
Refined wood creosote No. 200	2	96.
Tarco	2	88.5
Coal tar creosote and carbolite No. 22	12	83.3
Crude turpentine No. 75	2	77.5
Creco	3	77.3
Hemlock	4	76.
Crude wood No. 500	2	74.
Castor	12	73.4
Pure pine No. 5.	2	72.5
Pine tar creosote No. 7	4	70.2
Special pine tar creosote No. 8	2	67.6
Linseed	8	63.5
Sludge (insol.)	4	61.
Wood creosote No. 17	4	59.

¹Bancroft, Ore Flotation. This Journal, June 1, 1916.

TABLE VIII—HIGHEST CONCENTRATES IN LOW ACID PULPS

Medium	Pounds per Ton of Ore	Per Cent Zinc in Concentrates
Castor	4	47.51
Corn	4	47.
Hemlock	1	46.3
Rape seed	12	43.87
Linseed	8	43.71
Cotton seed	4	43.7
Coal tar creosote and carbolic No. 22	8	43.
Olive	12	41.47
Crude turpentine No. 75	1	39.6
Sludge (insol.)	3	38.15
Pure pine No. 5	4	38.1
Wood distillate	6	37.4
Fish	4	36.
Tarco	1	35.6

TABLE IX—HIGHEST EXTRACTIONS IN LOW ACID PULPS

Medium	Pounds per Ton of Ore	Per Cent Extraction
Hemlock	4	83.
Refined wood creosote No. 200	2	81.4
Crude turpentine No. 75	2	80.6
Creco	3	80.
Pine tar creosote No. 7	4	79.
Linseed	12	68.5
Tarco	2	67.
Sludge (insol.)	4	66.1
Wood creosote No. 17	4	61.
Pure pine No. 5	4	55.5
Rape seed	20	55.
Crude petroleum	12	48.0
Coal tar creosote and carbolic No. 22	8	48.
Wood distillate	4	48.

TABLE X—HIGHEST CONCENTRATES IN HIGH ACID PULPS

Medium	Pounds per Ton of Ore	Per Cent Zinc in Concentrates
Linseed	6	55.71
Pure pine oil No. 5	2	53.2
Sunflower	12	53.2
Cotton seed	8	52.7
Corn	8	47.
Rape seed	12	45.7
Castor	12	42.8
Olive	20	41.46
Crude carbolic	0.5	41.03
Hemlock	2	39.45
Refined wood creosote No. 200	0.5	37.90
Coal tar creosote and carbolic No. 22	8	34.
Creco	3	30.
Eucalyptus	4	29.3

TABLE XI—HIGHEST EXTRACTIONS IN HIGH ACID PULPS

Medium	Pounds per Ton of Ore	Per Cent Extraction
Eucalyptus	4	98.
Wood creosote No. 17	2	88.2
Refined wood creosote No. 200	2	85.2
Pure pine oil No. 5	4	77.4
Rape seed	12	60.3
Castor	12	60.
Pine tar creosote No. 7	4	59.
Linseed	8	52.
Cotton seed	8	48.
Sunflower	12	48.
Olive	20	46.1
Corn	8	43.
Creco	20	42.5
Wood distillate	8	39.

The results of Tables 6 to 13 are taken from the several tests arranged under Table I, in order to show a few of the richest concentrates and the highest extractions obtained in neutral, acid, and alkaline pulps. Twenty-eight (28) oils or mediums were tested in each of the above pulps, and in all conditions, save the alkaline, most of these mediums were tested by using three (3) different quantities.

Conclusions

1. The tailing used is easily amenable to successful

TABLE XII—HIGHEST CONCENTRATES IN ALKALINE PULPS

Medium	Pounds per Ton of Ore	Per Cent Zinc in Concentrates
Tarco	1	47.
Cotton seed	2	43.8
Creco	1	37.4
Crude petroleum	4	36.4
Coal tar creosote and carbolic No. 22	4	36.2
Fish	4	31.
Corn	20	28.36
Crude wood turpentine No. 75	1	28.1
Olive	8	26.6
Sunflower	4	26.3
Hemlock	2	25.
Crude wood oil No. 500	1	24.4
Wood distillate	2	24.04
Wood creosote oil No. 17	2	23.18

TABLE XIII—HIGHEST EXTRACTIONS IN ALKALINE PULPS

Medium	Pounds per Ton of Ore	Per Cent Extraction
Sp. pine tar creosote No. 8	1	84.
Hemlock	2	80.
Pure pine No. 5	2	80.
Wood distillate	2	78.5
Corn	20	77.5
Eucalyptus	2	71.
Wood creosote No. 17	2	68.
Crude wood turpentine No. 75	1	66.3
Pine tar creosote No. 7	2	60.
Ref. wood creosote No. 200	1	54.
Tarco	1	50.
Rape seed	10	46.4
Cotton seed	2	46.
Crude petroleum	4	45.5

flotation under many simple and economical conditions.

2. In general, the above tests on a zinc sulphide tailing show that in neutral and acid pulps, vegetable oils and the lighter wood distillates show good selection for the mineral and yield rich concentrates, while creosotic and phenolic mediums, on the other hand, do not show such selection between mineral and gangue, but yield high extractions. Some exceptions occur, however, and in the alkaline pulps the above observation does not apply.

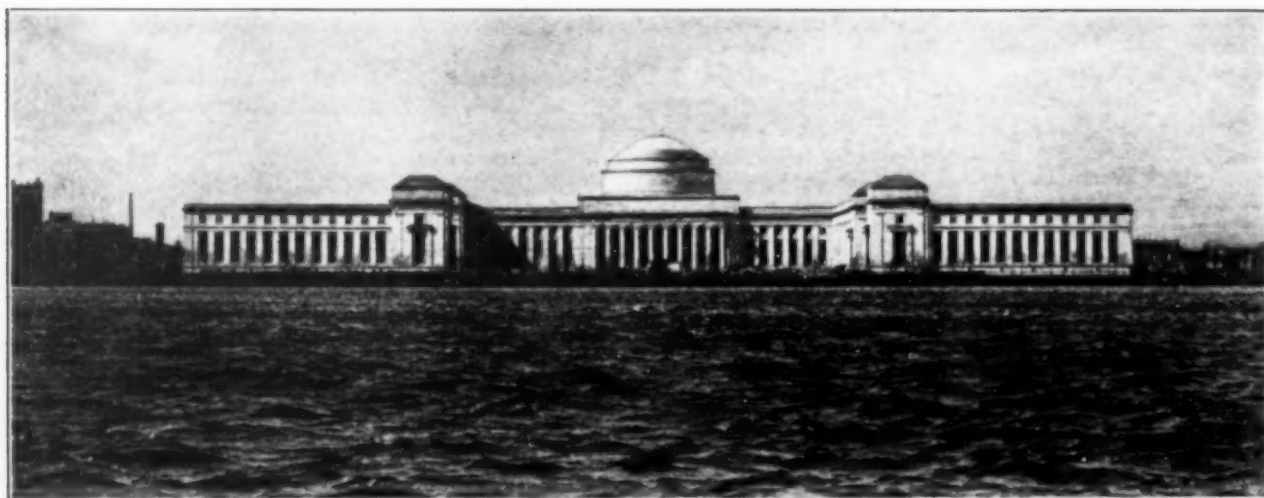
3. The richest concentrates and the highest extractions were produced in the high acid pulp.

4. The most effective results probably would be obtained by using a good "concentrating" medium mixed with a good "extracting" medium, i.e. a combination of the mediums mentioned under (2).

Note.—Since the foregoing laboratory tests were made some successful experiments have been carried out at Galena, Kansas, with a commercial-size unit. Some of the oils listed above were used, and also combinations.

Division of State Chemical Research,
University of Kansas,
Lawrence.

Electric Furnace Anniversary.—A banquet commemorating the first anniversary of the initial heat poured in the Gronwall-Dixon electric steel melting and refining furnace was given Saturday night, July 22, at the Detroit Athletic Club by the John A. Crowley Company of Detroit, who control the United States and Canadian selling rights of this furnace. Attending the banquet were the heads of the engineering, laboratory, metallurgical, operating, sales, and clerical departments. The pouring of the first heat in the Gronwall-Dixon electric furnace, located at Michigan and Hubbard Avenues, Detroit, was the beginning of the first electric steel industry in Detroit. During the past year more than 5000 tons of chrome-vanadium, nickel-chrome, nickel, and other high-grade steels, have been made and poured from this furnace. A new and modern plant is being completed in Detroit having 10-ton units with 30,000 tons yearly output.



THE NEW MASSACHUSETTS INSTITUTE OF TECHNOLOGY

A School of Chemical Engineering Practice

BY WILLIAM H. WALKER

In the address delivered by President Maclaurin at the dedication of the new buildings of the Massachusetts Institute of Technology, published in full in the July 1 issue of this journal, he stated, "This—the adequate supply of properly trained men—is the cardinal doctrine of industrial preparedness recognized by thinking men to-day as one of the greatest necessities of the times."

While there will always exist some difference of opinion as to what constitutes a properly prepared man, there are certain qualifications with which he must be provided. For example, he must be well grounded in science, trained in the applications of its principles to daily problems, have acquired engineering points of view and angles of approach, and have developed business perspective with relation to industrial work. In short, there must be produced the *potential* engineer. When a man has acquired a solid foundation in science, has become an accurate observer, an exact and logical thinker, and has developed a love for the application of this knowledge to the investigation and solution of the many problems which industrial practice presents, he has done marvelously well; but he still lacks much that goes to make the successful engineer.

While it is true that the resourcefulness in applying theory to practice, the training in the solution of industrial problems, the general business perspective, and self-reliance, which in time complete the man's education and make him a *creative* engineer is obtained in its entirety only by years of experience, there is much which engineering schools have accomplished to render more quickly available the scientific education of the embryonic engineer. Without well equipped mechanical and electrical laboratories it would be a long and difficult step to pass from the small apparatus and light load of a physics laboratory to the heavy responsibilities of a power plant. But in operating and testing the commercial-sized units with which mechanical engineering laboratories are readily equipped, a measure of self-confidence and an appreciation of responsibility are obtained not otherwise possible. In addition to all this, the student translates for himself the fundamental principles of physics as exemplified in the laboratory into the application of these same principles in units and processes of commercial size and value.

But such facilities have to a very limited extent been available for instruction in chemical engineering. The

important and oft-times controlling difficulties inherent in carrying on a chemical process on a manufacturing scale are not present when this same process is conducted in a chemical laboratory. To duplicate the apparatus which has been designed and built for factory operation is possible, and in many cases well worth while. But in order to study its performance the apparatus must be operated—a process for which it was designed must be carried out. This procedure is obviously expensive and at best limited in its scope. A student cannot acquire the self-reliance necessary to operate a high-pressure digester holding 25,000 gallons of acid by experimenting upon one of a few liters capacity. He cannot learn how to meet difficulties incident to handling a filter press, an electric furnace, a multiple effect evaporator, a rotary kiln, and so on, if he has access only to such apparatus as the laboratory can provide. That experience which means power to execute comes only from contact with commercial sized apparatus operating under the conditions imposed by practice.

Neither can the student obtain that training in the application of the principles of science to the problems of chemical industry on which successful industrial research so largely depends, without an opportunity to live with chemical processes which are being conducted on a large scale. It is true that the research chemist must be able to visualize the hitherto unaccomplished fact, but on the other hand, the undreamed accomplishments of the future, while using methods and equipment now unrealized, will also undoubtedly to a large extent employ the apparatus and the processes of to-day, although along new and varied lines. A familiarity with what does and does not succeed in present practice is the best foundation for that soundness of judgment so essential in every research worker, and most especially in those who are to direct and guide the activities of our industrial research laboratories.

In view of the impossibility of developing the type of engineer outlined without greater breadth of method and of contact than is possible in our educational institutions alone, it is generally recognized that the industries themselves have a duty to perform in this regard, and that without their co-operation educational accomplishment must remain imperfect. On the other hand, no satisfactory scheme involving industrial co-operation with educational institutions has hitherto been proposed, and the conception and inauguration of such a scheme cannot but represent an educational advance of the first order.

Within the last few years a comprehensive plan of great promise for the more adequate training of chemical engineers along these lines has been originated and developed by Mr. Arthur D. Little, a member of the Corporation of the Institute of Technology and chairman of the visiting committee for the department of chemistry. The plan has been enthusiastically adopted, and is based upon the idea of a close co-operation between the Institute and certain selected manufacturing organizations in representative industries. It involves radical changes in the Institute curriculum for chemical engineering, and the location of a part of the Institute's instructional activity in the manufacturer's plant.

As Mr. Little points out in his report to the Corporation of the Institute, "any chemical process on whatever scale conducted may be resolved into a co-ordinated series of what may be termed unit actions, as pulverizing, mixing, heating, roasting, absorbing, condensing, lixiviating, precipitating, crystallizing, filtering, dissolving, electrolyzing, and so on. The principles underlying each of these unit actions are the same, however different the materials operated upon may be. Thus in a gas absorbing system, the laws of counter current absorption which control the action of an ammonia scrubber do not differ from those involved in making sulfite digester acid. The number of these basic unit operations is not very large and relatively few of them are involved in any particular process. The complexity of chemical engineering results from the variety of conditions as to temperature, pressure, concentration, etc., under which the unit actions must be carried out in different processes, and from the limitations, as to materials and construction and design of apparatus, imposed by the physical and chemical character of the reacting substances. It is possible to so select a relatively few industries that there will be represented by them all of the important unit actions of chemical industry."

Experience has shown that when proper provision is made the performance of a piece of apparatus may be studied without materially interfering with its output. Thus the principles of multiple effect evaporation or of counter-current lixiviation can best be understood by making properly designed tests upon a working plant involving these unit actions. In other words, it is possible, under careful regulation, to use a manufacturing plant as a chemical engineering laboratory, and not cut down its production or influence adversely the quality of product. Some of the advantages of such a method of engineering practice over a laboratory equipped for instruction only are:

1. A first-hand knowledge of the machines with which the plant is equipped, operating under conditions imposed by practice, the processes involved being considered as unit actions, the factors which control their efficient performance, and a general knowledge of the cost of chemical apparatus in its relation to cost of installation and operation.

2. A study of the unit operations of the plant and the process which is being carried on, as examples of the application of the principles of science to industry, their interpretation in terms of physics, chemistry and mechanics.

3. A general knowledge of modern methods of factory management and control, obtaining thereby some familiarity with the problems presented by the human element in industry.

4. The education which comes from taking part in the work of the plant; in acquiring some degree of self-confidence in handling industrial processes and large-sized apparatus.

To carry into execution Mr. Little's idea, a *School of*

Chemical Engineering Practice has been organized, which will increase in scope as experience is acquired. For the present it consists of five stations selected to furnish opportunity in specific fields of broadest general importance in chemical engineering. Each station will include a small instructional laboratory, drafting room and conference room, and will be provided with a projection lantern, such special library, drawings, and models as may be needed. It will be in charge of a director, who will be a member of the Institute faculty.

Station A. Located with the Eastern Manufacturing Company, Bangor, Me. Here will be studied:

1. That most important application of the principles of electrochemistry to reactions taking place in solution, namely, the decomposition of common salt, with the formation of hydrogen, caustic soda and chlorine. The unit operations here available for study are electrolysis, multiple effect evaporation with separation of a crystalline precipitate, caustic soda purification and concentration; absorption of gas of low partial pressure; agitation of both heavy and light liquids, and sedimentation of sludge.

2. The manufacture of bleached spruce pulp by the sulfite process. This is a high pressure-temperature reaction under careful analytical control, which involves most interesting equilibria.

3. The manufacture of poplar pulp by the soda process. In this process a study of the losses of soda through the cycle of operations is a most instructive one. It involves precipitation, sedimentation, filter press separation, systematic lixiviation and washing, and a determination of the soda lost in furnace flue gases by the Cottrell electrostatic separation principle.

4. The boiling, bleaching, and beating of rags for paper stock, and the manufacture of bond and ledger paper. This is both beater and tub sized, and is partly drum and partly loft dried. The opportunities for chemical engineering study here are obvious.

Station B. Located at Everett, Mass., with the New England Gas & Coke Company. Without going into detail, the opportunities here offered are readily appreciated. The company operates large by-product coke ovens and water gas plants, with all the apparatus incident to the recovery of naphthalene, benzol, toluol, tar, ammonia, etc. Every opportunity is here presented to study those high temperature reactions of hydrogen with various hydrocarbons which have become so important in recent years.

Station C. Located at Niagara Falls with the Carborundum Company. High temperature electrochemistry is here represented in all its phases. Powerful electric furnaces of both the resistance and arc types are in operation, making a variety of products. The apparatus for pulverizing, with accurate separation, is here seen at its best, systems of sieving and screening, hydraulic classifying, and pneumatic separation being in constant operation.

Station D. Located at Stamford, Conn., with the American Synthetic Color Company. At this plant will be studied the chemical engineering of organic chemistry. Fractional distillation, sulfonation, alkali fusion, nitration, reduction, crystallization, with all the necessary apparatus, are but a few of the operations here available.

Station E. Located near Allentown, Pa., with the Atlas Portland Cement Company. Large scale operations involving crushing and grinding in many types of machines are here offered. The chemistry of combustion and furnace control is nowhere studied to better advantage than in the mammoth kilns of this plant.

To obtain the greatest good from such splendid opportunities it is clear that this school must be a part

of a consecutive and consistent course of study. Not only must an adequate scientific foundation be laid before undertaking this chemical engineering practice, but provision must be made for taking advantage of the directness of purpose and enthusiasm for further scientific study which the factory work will create. This is accomplished by providing a Master's course in chemical engineering of five years' duration, including the entire summer between the fourth and fifth years.

The first three years are identical with those of the four-year Bachelor's course in chemical engineering as now offered at the Institute. At the end of the third year the student will elect either to finish the regular course of four years, receiving therefor the Bachelor's degree, or to spend two years and the intervening summer in study and receive both the Bachelor's and Master's degrees. From those students who elect this Master's course, including the school of chemical engineering practice, the faculty will select those whose attainments and character as shown by their previous record of scholarship and by other information are such as to indicate that the course can be creditably pursued.

At the beginning of the fourth year the men so selected will be divided into five groups, and one group sent to each of the five stations for a period of six weeks. (Experience may prove that this is too short a time to accomplish the greatest good.) At the end of each six-week interval the groups will change stations, so that by Sept. 1 each group will have occupied each station. After from three to four weeks' vacation these men will all return to the Institute for the fifth year of advanced work, graduating the following June.

It must be kept in mind that the students going out into these various industries do not go as employees of the industry, but as students in the school of chemical engineering practice. It is intended that the work in the plant shall be wholly educational, and the men are to be under the control and direction, not of the plant organization but of the director of the station, a member of the educational staff of the Institute.

While it is intended to give the men as much industrial experience as possible, having them take shifts in the ordinary routine of the factory, such work will be directed throughout to secure the maximum educational result, and the interpretation of the experiences and results of work in the plant will be accomplished by conference and drawing room exercises, which will take up no small fraction of the time spent in each station. It is expected in this way to avoid the weakness and inefficiency of previous schemes of co-operation by making no attempt whatever to have the student an economic asset to the industry, but planning his whole activity for its educational return to the student himself.

To secure this high educational efficiency from the contact of the student with the industry, it will be noted that the student has completed substantially the equivalent of a four-years' course in chemical engineering before entering upon the school of practice. This will make possible the full appreciation of the significance of every fact and the interpretation of every experience in the light of fundamental principles.

The work of the fifth year is advanced in character, broad in scope, and almost wholly elective, the purpose being to take advantage of the student's enthusiasm and to allow him to specialize in the line in which he has found by experience that he has the greatest aptitude and interest.

But the plan is a co-operative one, and while it is confidently expected that in the work carried on by these students entirely for its educational value, there will result an accumulation of data, much of which will

be of service to the industry concerned, yet this prospective return is not figured as an asset to the plan. As a return for the use of the factory as a chemical engineering laboratory the Institute proposes to establish and direct for each company concerned a research organization devoted entirely to the solution of its individual problems. While a laboratory will be maintained at each station, the extensive research facilities of the Institute will be available for work of a special character, and the faculty of the Institute will function as a consulting staff.

The earning power of industrial research is now too firmly established to require any argument to demonstrate the possibilities for co-operative service which the plan possesses. It is earnestly hoped that in it may be found an effective method by which science may be more closely linked to industry for the lasting benefit of each.

Hygroscopic Properties of Sodium, Potassium and Ammonium Nitrates, Potassium Chlorate and Mercury Fulminate

BY GUY B. TAYLOR AND W. C. COPE

One of the most important properties of substances used in explosive manufacture is that of behavior toward moisture. Thorough drying of many of the ingredients of explosives is required before mixing and many explosives must be packed in moisture-proof containers to prevent subsequent moisture absorption from the air.

The following experiments were undertaken by the Bureau of Mines in connection with studies of detonators (blasting caps) as the failure of a detonator is often a serious matter, and many failures are attributed to wet composition in the detonator charge. Precise information was sought regarding the conditions under which the mercury fulminate-potassium chlorate mixtures generally used in detonators would take up moisture from the air, and the rate at which it was absorbed. The salts sodium, potassium, and ammonium nitrates, are much used in explosives and were included in the studies, the methods of which are given below.

The behavior of soluble salts, not forming crystalline hydrates, toward atmospheric moisture follows very simple laws. If the partial pressure of the water vapor in the air exceeds the vapor pressure of the saturated solution of the salt, then the salt will take up moisture; if the partial pressure of water vapor in the air is less than the vapor pressure of the saturated solution no moisture will be taken up by the salt, but it will lose water to the air. If the two pressures are equal, then equilibrium occurs, and there is no exchange of moisture between the salt and the atmosphere. It should be noted, however, that this state of equilibrium does not correspond with any definite water content of the pure salt. Since the vapor pressure of pure water is always greater than that of any aqueous solution, it is evident that any substance containing a soluble constituent can never be in equilibrium with an atmosphere saturated with water vapor.

Observations concerning the absorption of atmospheric moisture have been made by various investigators: fertilizer materials by Brownlee,¹ soils by Lipman and Sharp,² and black powder by Kullgren.³ Studies on rate of absorption of moisture by sodium and ammonium nitrates, and explosives containing these salts

*Published by permission of the Director of the Bureau of Mines.

¹J. Ag. Sci. 2, 380-1.

²J. Phys. Chem. 15, 709-22.

³Z. ges. Schless-Sprengstoffw.—6, 364 and 385.

when stored over sulphuric acid solutions have been made by the French Explosives Commission', Busnikoff and Schuyten' have also studied the rate of moisture absorption by salts.

Rate of Moisture Absorption in a Saturated Atmosphere

In measuring the rate of moisture absorption, the material was exposed in an open porcelain crucible over water under carefully regulated conditions and the increase in weight noted after lapse of certain periods of time. Ordinary quart jars closing with glass tops and spring clamps were filled 2 cm. deep with distilled water; into each jar was placed a copper wire tripod for supporting one crucible. The jars were then closed and submerged completely under water in a large thermostat. When sufficient time had elapsed for jars and contents to come to the bath temperature, they were elevated so that the necks emerged, the tops removed, and the crucibles placed on the tripods. After closing, the jars were again submerged. In order to prevent possible condensation of moisture the crucibles were warmed slightly above the bath temperature before being placed in the jars.

The thermostat was a large tank of water, 30 by 26 by 20 in., electrically heated and stirred and controlled by a toluene thermo-regulator within less than 1/10 deg. Keeping the jars at a constant temperature prevented condensation of moisture on the walls and assured constant conditions of humidity.

When a crucible was removed from its jar, it was covered with an aluminum cover and weighed immediately since it lost weight fairly rapidly in laboratory air. Each result was obtained from a separate crucible, none being returned to the jars after weighing. The crucibles were about 2 cm. deep and had flat bottoms 3.7 cm. in diameter so that the material was spread out over a surface of about 10.75 sq. cm. The following results were obtained at 25 deg. from 2.0000 grams of

TABLE I—RATE OF MOISTURE ABSORPTION IN SATURATED ATMOSPHERE

	Hours	H ₂ O Absorbed, Grams
NH ₄ NO ₃ (40-80 mesh)	3	.1234
	5 1/4	.2087
	7 3/4	.2913
	16 1/2	.6387
NaNO ₃ (40-80 mesh)	3	.0713
	5 1/2	.1355
	7 1/2	.1970
	16	.3924
KNO ₃ (40-80 mesh)	2 3/4	.0147
	18 3/4	.1136
	25 1/4	.1527
	42 3/4	.2687
	47	.2898
KNO ₃ (ground very fine)	7 1/4	.0453
	16 1/2	.1056
	40 1/2	.2580
95 per cent KNO ₃ , 5 per cent NaNO ₃ ..	2 3/4	.0752
	4 1/2	.1195
	7 3/4	.1960
	16	.2990
	20	.3592
	25	.4010
KClO ₃ (40-80 mesh)	45 1/4	.0660
	69 3/4	.1056
	93 1/2	.1392
	122 3/4	.2340
KClO ₃ (ground very fine)	16	.0248
	69	.1062
	88 3/4	.1488
HgC ₂ N ₂ O ₃ (F)	142	.0262
HgC ₂ N ₂ O ₃ (M-1991)	164	.0157
90 per cent HgC ₂ N ₂ O ₃ , 10 per cent KClO ₃	17	.0290
	41	.0642
	69 3/4	.0980
	95 3/4	.1360
	116 1/2	.1674
80 per cent HgC ₂ N ₂ O ₃ , 20 per cent KClO ₃	16 1/2	.0316
	45 1/2	.0675
	64 1/4	.1000
	92 1/2	.1400

*Mem. poud. et. salp. 16, 9-10 (1911-1912).

*J. Russ. Phys.-Chem. Soc. 32, 551-593 (1900).

*Bull. soc. chim. Belg. 26, 101.

material. The salts used were highest grade C. P. preparations, the ammonium nitrate Bakers and the other three salts Kahlbaum's "brown label." The fulminate-chlorate mixtures were taken from commercial detonators (blasting caps).

If the increases in weight be plotted against time the points for the pure salts fall very closely on straight lines. The curve for a mixture of the two salts, sodium and potassium nitrates, with only 5 per cent NaNO₃ first follows the NaNO₃ line and then inclines toward the KNO₃ line. (See Fig. 1.) The points for the two potassium chlorate-mercury fulminate mixtures lie close to the KClO₃ line. These results are as may be ex-

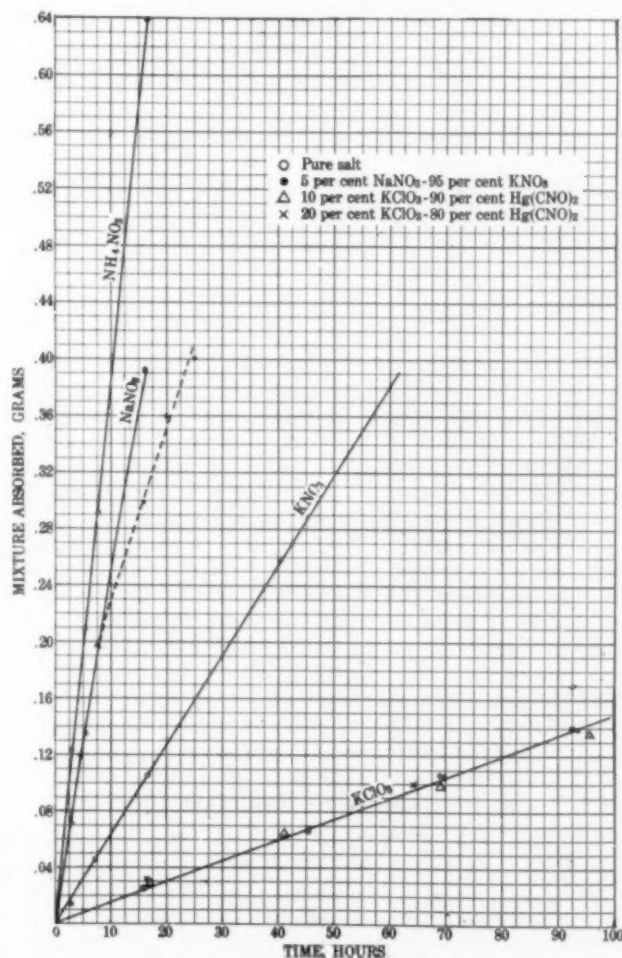


FIG. 1—HYGROSCOPIC CURVES

pected from theory. The vapor pressure of a saturated solution in equilibrium with two solid salts will be at least as low as that of the constituent whose saturated solution vapor pressure is lower, which will in general be the more soluble salt. The NaNO₃ — KNO₃ containing only 5 per cent of the former begins to absorb moisture at the rate of pure sodium nitrate, which becomes slower as the amount of water taken up increases and the NaNO₃ goes into solution, eliminating one of the solid phases. Mercury fulminate is so slightly soluble that its influence in lowering the vapor pressure of the saturated solution of potassium chlorate is small, and mixtures of these two salts take up moisture at about the same rate as the pure chlorate.

It will be noted that the chlorate-fulminate mixtures absorbed approximately the same actual weight of moisture in a given time as the pure chlorate although the quantity of actual chlorate present was only one-tenth and two-tenths as much. It was found by experiment that in thin layers and with the same exposed surface, the quantity of moisture absorbed in a given time was

independent of the weight as well as the fineness, within certain limits. For example 0.5 grams KClO_3 absorbed the same weight of moisture as 2.0 grams when exposed to a saturated atmosphere under identical conditions.

The results of Table II were obtained by exposing 2.0 grams of the salt over water in the same manner as above but at 35 deg. C.

TABLE II

	Hours	H ₂ O Absorbed, Grams
KNO_3	1 $\frac{3}{4}$	.0310
	4	.0612
	4 $\frac{1}{2}$	.0733
	19 $\frac{1}{2}$	.3137
KClO_3	20 $\frac{3}{4}$	.0847
	44 $\frac{3}{4}$	.1740
	68	.2887

Sodium nitrate in a partially saturated atmosphere, that is, over a saturated solution of potassium nitrate absorbed moisture as follows, 2.0 grams at 25 deg. C.:

7 hours.....	.1218 g.
16 hours.....	.2928
39 $\frac{1}{2}$ hours.....	.6955

Several experiments were made by exposing KNO_3 contained in vessels of varying heights and diameters filled to different depths with the salt. The weight of moisture absorbed in a given time in a saturated atmosphere is very materially affected by all these factors. In tall weighing bottles the rate of diffusion of water vapor evidently played an important part in determining the result. These results emphasized the importance of constant conditions in obtaining comparative results with the several materials. It should be pointed out, however, that the most important condition is maintaining constant conditions of humidity. For this reason exposing substances on watch glasses over water in ordinary desiccators at room conditions is a wholly unsatisfactory procedure for comparing the relative hygroscopicity or deliquescence.

Vapor Pressure of the Saturated Solutions

Marshall¹ has arranged a table of "relative deliquescence" of crystalline substances used in explosives assigning the value 1 to KNO_3 . The relative humidity, i.e., per cent air saturating in equilibrium with each salt for which there was no direct data, was calculated from Raoult's law. This figure subtracted from 100 and divided into the value for KNO_3 gave the "relative deliquescence." The values thus obtained at 20 deg. were for NH_4NO_3 , 7.6, NaNO_3 , 3.4, KNO_3 , 1.0, and KClO_3 , 0.23, while from the writers' experiments at 25 deg. C. the values are 6.3, 4.0, 1.0, and 0.23 respectively, which accord very well with Marshall.

Marshall's calculations are based on the assumption that the rate of moisture absorption is proportional to the difference between the partial pressure of water vapor in the air and the vapor pressure of the saturated solution. If this is true, from a knowledge of the vapor pressure of the saturated solution of one salt and the relative rates of moisture absorption in a saturated atmosphere, it ought to be possible to calculate the vapor pressure of saturated solutions of other salts.

The best available vapor pressure measurements of saturated solutions at ordinary temperatures are those of Speranskii.²

He used a tensimeter and measured the solution against distilled water. In the following table in the columns headed "calculated," the results were obtained from Speranskii's value for KNO_3 , 21.94 mm. at 25 deg. C. and our results on moisture absorption, together with Regnault's values for the vapor pressure of water, 23.55 mm. at 25 deg. and 41.83 mm. at 35 deg. C. These values for water are lower than those now generally accepted but were used in order to make use of Speranskii's formulas in calculating the observed vapor pressures of the saturated solutions.

	25 DEGREES		35 DEGREES	
	Calculated	Observed	Calculated	Observed
NH_4NO_3	13.4 mm.	.....	.....	.....
NaNO_3	17.11	.....	.....	.....
	17.29 (a)	17.52	.....	.....
KNO_3	21.94 (b)	21.94	37.95	37.59
KClO_3	23.18	23.02	41.13	40.77

(a) Calculated from results over KNO_3 solution

(b) Used in all calculations.

The agreement between the observed and calculated values is well within all the experimental errors.

Absorption of Moisture by Detonators

The results obtained with the detonator compositions of mercury fulminate and potassium chlorate showed that the hygroscopic character of these compositions is almost entirely due to their chlorate ingredient. Tests were then made with commercial detonators of different grades, storing them over water in the jars in the thermostat. The results obtained showed that the rate of absorption is the same for all detonators having the same diameter, and is independent of the chlorate content and weight of the charge. The actual rate of absorption is shown to be very nearly proportional to the differences in the vapor pressures of pure water at the two temperatures and the vapor pressure of KClO_3 saturated solution. No. 5 detonators do not properly detonate with a moisture content as low as 0.01 gram per detonator. It should be noted, however, that fulminate-chlorate composition does not absorb atmospheric moisture at all unless the air is almost saturated, that is about 97 per cent between 0 deg. C. and 35 deg. C. a condition that obtains in practice only under exceptionally bad storage conditions.

MOISTURE ABSORPTION BY DETONATORS

Time, Days	MOISTURE ABSORBED at 25 DEG. C.			Time, Days	MOISTURE ABSORBED at 35 DEG. C.		
	L-178	M-54	M-1661		L-178	M-54	M-1661
2	.0020	.0019	.0016	3	.0080	.0080	.0082
4	.0041	.0038	.0038	8 $\frac{1}{2}$	.0217	.0215	.0222
6	.0061	.0061	.0065				
17	.....	.0178	.0186				
25	.0262	.....	.....		

L-178—No. 5 detonator containing .70 gram charge of 90 per cent fulminate and 10 per cent chlorate.

M-54—No. 7 detonator containing 1.45 gram charge of 90 per cent fulminate and 10 per cent chlorate.

M-1661—No. 8 detonator containing 2.00 gram charge of 80 per cent fulminate and 20 per cent chlorate.

SUMMARY

The results described in this paper show that the hygroscopic properties of salts are a function of the humidity of the air and the vapor pressures of their saturated solutions. The relative rates of moisture absorption are proportional to the difference between the

¹Marshall, A.: "Explosives. Their Manufacture, Properties, Tests and History." (1915) pp. 338-341.

²Z. physik Chem. 70, 519, and 78, 86.

partial pressure of moisture in the atmosphere and the vapor pressure of the saturated solution of the salt.

From a measure of moisture absorption, vapor pressures of saturated solutions may be calculated.

The tendency of detonators (blasting caps) to take up moisture from the air has been shown to be almost entirely due to the potassium chlorate which they contain.

Explosives Chemical Laboratory,
Bureau of Mines,
Pittsburgh, Pa.

Revision of Our Chemical Statistics

BY BERNHARD C. HESSE

In a paper presented at the Philadelphia meeting of the American Institute of Chemical Engineers it has been pointed out that our chemical statistics need revision; a general plan or outline of plan therefor was then presented. At the Seattle meeting of the American Chemical Society in September, 1915, a committee was appointed to devise some practical and practicable way of obtaining such revision and of putting it into useful and serviceable effect. The organization of that committee was not completed until June, 1916. The reason for this delay is that service upon this committee entails a large amount of very difficult and most tedious labor, and men hesitate to assume such added responsibilities. Successful execution of this plan calls for co-operative thinking and planning on the part of all members of all chemical societies of this country and of all those engaged in chemical pursuits of any industrial or commercial aspect in this country.

Inspection of the lists of European countries for the past twenty years, so far as they relate to chemicals and allied materials, shows that these lists have been very greatly expanded and indeed much more so than our own.

In general, each European country seems to arrange its list with a view of telling its own people the most about other peoples and of telling other peoples as little about their respective affairs as is convenient, particularly in those items which are capable of high diversification. For example, the German list divides 120,000 short tons, or \$54,250,000 = 21.5 cents per pound of coal-tar dyes into four items only; photographic chemicals totaling 3080 short tons, or \$2,000,000 = 32.5 cents per pound, are lumped into one item, and 1320 short tons, or \$5,300,000 = \$2 per pound, synthetic pharmaceuticals also take up but one item. These six items total 124,400 short tons, or \$61,550,000, and average \$495 per ton, or 24.7 cents per pound, and cover fully 1800 different articles of manufacture, only few of them closely related; 123 short tons of various alkaloids and their salts of a total value of \$1,750,000, or \$14,220 per ton, or \$7.11 per pound make up one export item.

On the other hand, Switzerland in its lists is more diversified as to its imports from Germany than Germany is in its list of exports to Switzerland; in fact, Switzerland seems to enter and report trademarked or proprietary synthetics and the like as such; our own lists do this in isolated cases only.

German statistics for the calendar year are published within the first five weeks of the succeeding year; our own reports are two or three months later.

On its face, it seems plausible that if we are now to diversify our domestic chemical industry rapidly, and with the fewest false steps and commercial or industrial calamities, we should be advised in some authoritative manner as to the nature of our domestic market

as it is now and may develop to be in the future. If under these conditions we do not properly develop our markets and our domestic manufacture, we at least cannot reasonably raise the defense that we did not do better because we had no way of determining what our country's needs were, and therefore could not intelligently plan our independence from foreign supply sources.

I am encouraged in a belief in this utility and benefit by the rather large number of inquiries that have been made of me personally, orally and by letter, within the past twenty months for information as to the domestic consumption of this, that or the other imported article, and in only the fewest instances have I been able to dig up an answer that filled the bill.

It seems to me that there can be no debate on the general proposition that the more we know about our market requirements the more likely are we to build up a domestic industry. Add to this the fact that at comparatively little added expense our federal government, through one or more of its departments, can gather and promptly publish such added information, and it seems to me to be conclusive that the chemists of this country should get together, make up a list of such specific added items they need to be informed about, and indicate such further diversifications of items as to them promise the greatest help in the future.

We can rest assured that the number of different chemical materials and products that this country will use and continue to use will be not at all diminished in the future, but quite on the contrary will be greatly and very likely rapidly increased. The longer we put off such diversification of our lists the harder the task of future diversification will become; it will certainly not become any easier.

Such a request for added information has nothing in common with asking for a subsidy or a bonus or added tariff protection; it is simply a request to be better informed as to the requirements of the public so that we may more intelligently work towards our nation's industrial independence of foreign supply sources; in so helping us the public will be helping itself.

In presenting to the proper authorities a request for added information we must make as reasonably sure as possible that whatever is presented is not half baked, but is as mature as circumstances and conditions will permit; that it meets with and embodies the views of the great majority of those likely to be affected by this information, and that there is a reasonable stability to that list; such request should be in as definite final form as possible.

Clearly, the constructing of such a request is by no means whatever the duty of any one man or of any small group of men; it is a duty in which every person in the country engaged in the making, selling and distributing of articles of this class fully shares; in fact, it is everybody's business. The committee of the American Chemical Society can act merely as a clearing house for requests, and then put them into a form that will be likely to receive the sympathetic attention and enlist the active co-operation of the officials who must supervise the details of gathering and publishing such material.

As chairman of this special committee of the American Chemical Society I have prepared a consolidated list of articles used or produced in or by chemical industries as they appear in the most diversified commercial reports of Austria, France, Germany, Great Britain, Italy, Sweden and Switzerland; italicized entries are to be found in the most diversified U. S. lists. This consolidated list is as follows:

LIST I

I—MALT, OIL, FRUITS, INDUSTRIAL PLANTS, FRUITS AND PLANT JUICES

Malt, excl. burnt and ground.
Rapeseed.
Castor beans.
Poppy and sunflower.
Linseed and meal.
Palm kernels.
Kopra.
Hops.
Madderroot, Quercitron and other dye plants.
Opium.
Kino.
Aloe and other fruit and plant juices.

II—VEGETABLE PRODUCTS FOR INDUSTRIAL OR MEDICINAL USES

Cinchonabark.
Rhubarb root.
Gentian root.
Curcuma.
Cudbear.
Caraway, Iceland moss and other crude lichens; Tamarinds, stick-cinnamon; berries, leaves, flowers, etc. for medicinal uses. Insect powder and flowers.
Tea for caffeine.
Vegetable waxes in natural state.
Wood for wood pulp, etc.
Wood charcoal and powder, charcoal briquettes.
Wood, flour and excelsior.
Roots for distillation. Roots for medicinal use.

III—DYEWOODS AND TANNING MATERIALS

Logwood.
Fustic, Brazil wood.
Orehil.
Ground or fermented dyewoods.
Quebracho and other woods, in blocks.
Quebracho and other woods, ground.
Algarobilla, Dividivi and other n. s. p. f.
Valonia.
Nutgalls.
Myrabolans.
Sumach.
Catechu (brown and yellow), gambier (crude or refined).
Oak bark.
Coniferous barks.
Mimosa, mangrove, maletto and other tan-banks.
Oak, pine and chestnut—extracts.
Nutgall—extract.
Quebracho—extract.
Sumach—extract.
All other tanning extracts.

IV—RESINS, LAKES, VARNISHES AND PUTTIES

Turpentine resins.
Kauri and other copals.
Damar, akaroid and other resins, olibanum and other soft resins; gum-resins.
Gum-lac.
Shell-lac.
Acacia, ocajon, cherry, cutera and bassora-gums.
Tragacanth.
Scammony.
Oil varnishes, Bird-lime ex linseed oil.
Spirit varnishes. Shellac-putty.
Lacquers (non-spirit), asphalt varnishes, coach varnishes.
Sealing waxes.
Putty and putties n. s. p. f.
Asbestos paints, asbestos pigments, asbestos putty.
V—CAOUTCHOUC AND CAMPHOR
Caoutchouc, crude or refined.
Gutta percha, crude or refined.
Balata, crude or refined.
Rubber, scrap or waste.
Caoutchouc substitutes.
Camphor and manna.

VI—ANIMAL AND VEGETABLE FATS AND OILS

Hog lard.
Oleomargarine.
Goose-fat, beef marrow, etc.
Prime beef tallow.
Beef and mutton tallow.
Bone-fat, fat-waste, stearin-pitch.
Fish, whale and seal oil.
Fats, etc., from fish, whale and seal.
Horse fat, deer-tallow, etc.
Rape oil.
Linseed oil.
Bean-oil.
Peanut-oil

Sesame oil.
Olive oil.
Lavai and sulfur oil.
Cotton seed oil.
Wood tar oils

Castor oil.
Beech, bone, corn, poppy, sunflower and other fatty oils.
Fat-oils in tins, bottles, etc.
Cocoa butter.
Cotton seed stearin.
Palm oil (palm butter-fat, etc.)
Palmkernel oil and fat.
Cocoanut oil fat and tallow.
Vegetable tallowes.
Vegetable Ivory.
Olein.
Margarine.
Edible vegetable tallow.

VII—ANIMAL PRODUCTS

Egg-yolk.
Egg-albumen.
Bees and other insect waxes, honeycombs.
Spermaceti.
Fish glue, agar-agar.
Glue-waste.
Bones, horns, hoofs, etc., not for cutting purposes.
Horn-waste for fertilizer.
Bone and other animal blacks; bone-ash.

VIII—STARCH, SUGAR

Potato starch, green or dry.
Rice starch.
Corn, wheat and other starches.
Starch gums, dextrins, burnt starch, paste, adhesives and gluten-meal.
Cane sugar.
Beet sugar.
Beet sugar, flats, sticks and cubes.
Beet sugar, ground.
Beet sugar, lump.
Beet sugar, ground refined.
Beet sugar, loaf.
Beet sugar, brown.
Beet sugar, confectioners.
Cane sugar, raw, solid or liquid.
Beet sugar, raw, solid or liquid.
All other solid and liquid sugars.
Syrups and molasses.
Starch, fruit and other fermentable sugars, burnt sugar.
Caramel, solid and liquid.
Invert sugar.
Milk sugar.

IX—ALCOHOL, VINEGAR, YEAST AND MINERAL WATER.

Alcohol, in barrels.
Alcohol, in bottles.
Vinegar of all kinds.
Methylated spirits.
Wine yeast.
All other yeasts.
Mineral waters, artificial, etc., incl. bottles.

X—MINERAL AND FOSSIL RAW MATERIALS

Alunite.
Clay, common, potters', fire and pipe.
Kaolin and china clay.
Burnt clay, chamotte, Fayence, etc.
Yellow, ochre, bole, Sienna and Verona earths.
Other earth-colors, artificial oxide iron, crude.
Chalk, white crude.
Graphite, crude, ground and washed.
Pumice, Tripoli, crude, ground, washed or in bricks or tile.
Emery, crude, ground or washed.
Mineral abrasives, polishes and cleansers, crude, ground or washed.
Enamels and glazes.
Kieselguhr, quartz-sand, fire-stones.
Lime, slaked, limestone or lime mortar.
Magnesia.
Magnesite, native or burnt.
Witherite, native or burnt, strontianite.
Lime phosphates (Apatite, phosphorite, coprolite, etc.).
Gypsum; gypsum - superphosphate.
Puzzolan, etc.
Portland and Roman cements.
Ground lime; tripolith.
Asbestos, crude.
Venetian chalk, crude, ground or burnt.
Talc, crude, ground or burnt.
Mica, crude.
Barytes and Celestite.
Feldspar, ordinary.
Fluorspar, crude; Kryolite, natural.
Boracalcite and Tincal.

Monazite-sand.
Fullers and other earths and bituminous shale.

XI—ORES, IRON, SLAGS

Antimony ore and matte.
Antimony regulus.
Arsenic ores.
Lead ores.
Chrome ores.
Iron ores.
Gold ores.
Copper ores, inclusive of pyrites cinders.
Copper regulus.
Manganese ores.
Nickel ores.
Platinum ores.
Pyrites (Pyrrhotite, marcasite, etc.).
Silver ores.
Tungsten ores.
Zinc ores.
Tin ores.
Uranium, molybdenum and other ores n. s. p. f.
Gas-purifying masses containing iron or manganese; slags, slag felts, slag wools; ferrocyanide, sludge; ashes, pyrites-cinder, etc.

XII—FOSSIL FUELS

Anthracite, bituminous and cannel coal.
Lignite.
Peat, peat-coke and peat fuels.
Coke.
Coal—briquettes.
Lignite—briquettes.
Coke-like residues and artificial fuels.
Carbons, formed and crude; vegetable carbon.

XIII—MINERAL OILS AND OTHER FOSSIL RAW MATERIALS

Lubricating and vaseline oils.
Crude petroleum; pitch and natural liquid asphalt.
Heavy gasolines, turpentine substitutes.
Gas oils.
Refined petroleum.
Crude gasoline.
Benzine, gasoline, ligroin, petroleum ether and similar refined light-oils.
Lignite, peat and shale-oils and other not otherwise specified mineral oils, tars and pitches.
Paraffine, crude and refined.
Soft paraffin.
Solid asphalt and asphalt bricks.
Asphalt-mastic, pitch, resin and wood cement.
Ozocerite and mountain-pitches, crude.
Refined ozocerite, ceresin.
Pitch and black wax.
Pitch-like petroleum residues heavier than water.
Shale-pitch; lignite tar, peat-tar, wood tar, birch tar.
Oil and water-gas tar.

XIV—COAL TAR OILS AND PRODUCTS

Coal tar.
Carbolineum.
Coal tar pitch.
Benzol, toluol, cumol, etc.
Anthracene, carbolic, cresote and other heavy coal-tar oils and asphalt-naphtha.
Solvent-naphtha.
Naphthalene.
Anthracene.
Phenol, crude or refined.
Lime carbolate.
Pyridine bases.
Cresol, crude carbolic 100 per cent.
Anilin, oil and salts.
Dimethylanilin.
Benzyl chloride.
Naphthol, naphthylamin.
Naphthol compounds.
Anthraquinone, nitrobenzol, Toluidin, Resorcin, Phthalic Acid and other coal tar products.

XV—WAXES

Prepared bees and other insect waxes.
Prepared vegetable waxes; vegetable wax waste.

XVI—SOAPS AND FAT PRODUCTS

Ordinary soft soap; oils and fluid fats, Turkey red oil; liquid Creolin and like cleansers; soap substitutes in barrels.
Hard soaps; Creolin and like hard cleansers; soap substitutes and evaporated lyes not elsewhere specified.
Cake-soaps; liquid soaps, soap powders, papers and other soap substitutes.
Stearin, palmitin.

Tapers, candles and night-lights.
Phonograph plates and rolls of wax or ceresin.
Crude glycerin.
Refined glycerin.
Soap waste lyes.
Paraffin ointment, vaseline, vaseline ointment, lanolin and lanolin preparations.

Rosin-soaps.
Debras.
Axie-grease.
Other lubricants made from fats or oils.
Shoeblackening, solid.
Yellow shoe polish.
Polishes made of fats, oils, soaps; alumina soap, artificial polishes.
Stearin, palmitin, etc., formed.

XVII—CHEMICAL AND PHARMACEUTICAL PRODUCTS

Abraum Salts; 12-15 per cent K₂O, more than 15-19 per cent K₂O.
Abraum Salts N. S. P. F.
Acetates, all other n. s. p. f.
Acetone oil.
Acid:

Acetic.
Acetylsalicylic.
Arsenic.
Arsenious.
Benzoic and sodium benzoate.
Boric.
Chlorosulfonic.
Citric.
Formic.
Hydrochloric (nitrohydrochloric).
Hydrofluoric.
Lactic.
Nitric.
Oxalic.
Phosphoric.
Salicylic and sodium salicylate.

Sulfuric:
Non-fuming.
Fuming.
For fertilizers.
Spent.

Tannic and gallic.
Tartaric.

Acid, Anhydrides.

Acetic.
Sulfuric.

Alkali and other metals not specified.

Alkaloids, all other, their salts and compounds.

Alum:
Soda, potash or ammonia.
Chrome, iron or copper.

Aluminum:
Acetate.
Chloride.
Hydrate, artificial.
Oxide, artificial.

Sulfate.
Sulfite.
Sulfocyanide.

Ammonia water.
Ammonium:
Carbonate.
Chloride.
Fluoride.
Nitrate.
Sulfate.

Anilin compounds, not dyes.

Antimony:
Fluoride.
Oxalate.

Regulus or metal.
All other compounds n. s. p. f.

Are Carbons.
Argols, crude or refined (soda or potash).

Artificial and natural mineral water salts.

Artificial balsams, extracts and waters, not perfumes.

Arsenic:
Metal.
Sulfide.

Compounds, all other n. s. p. f.

Barium:
Chlorate.
Chloride.
Hydrate.
Oxide.
Nitrate.
Peroxiside.
Sulphide.

Beetroot Potash.
Benzoates n. s. p. f.
Bismuth salts.

Borax.
Bromine.
Bromides of potash, soda, ammonia.

Bromides n. s. p. f.
Bromoform and Iodoform.
Bromine, organic compounds n. s. p. f.

Caffeine.
Calcium:
Carbide.

Chloride and liquors of
Nitrate (air).
Carbon bisulfide
Carbon tetrachloride
Carborundum
Carborundum discs
Carborundum paper
Carborundum, other manufac-
tures of
Carbides n. s. p. f.
Carnallite 5-12% K_2O
Casein and non-edible casein
preparations
Chemical products, n. s. p. f.
for photographic, cleansing
and other uses.
Chloral Hydrate
Chlorates, n. s. p. f.
Chlorine compounds, organic n.
s. p. f.
Chloroform
Chromes:
Acetate
Chloride
Oxide (hydroxide)
Chromous chloride
Cobalt salts n. s. p. f.
Cocaine, crude & refined
Cocaine, salts of
Collodion & celloidin
Copper sulfate (copper & fer-
rous sulfate)
Creosote, wood—peat & tar.
Cryolite
Cyanides, (potash or soda)
Disinfectants
Egg Albumen, dried & pow-
dered; albuminous materials
Epsom Salts
Ethyl bromide
Ethyl chloride
Ethyl iodide
Ferrosilicon with 25% Si or
more.
Fertilizer salts inclusive of
potash fertilizer with 30%
 K_2O
Fluorides
Fluosilicates
Formaldehyde
Formaldehyde-sulfoxylates
Fruit & plant juices containing
ether or alcohol
Gases, compressed:
Acetylene
Hydrogen
Nitrogen
Oxygen
all other liquified
Acetylene
Ammonia
Carbon dioxide
Sulfur dioxide
all other
Gelatine
Gelatine capsules
Glue:
crude
other than egg for printing
rolls
Gold:
chloride
all other salts of
Green:
Schweinfurth & similar
Hydrogen peroxide
Hypochlorites n. s. p. f.
Industrial chemicals n. s. p. f.
inorganic
organic
Inorganic chemicals for medi-
cinal use n. s. p. f.
Insecticides
Iron:
Acetate
Lactate
Mordant
Sulfate
Sulfide (artificial)
Iodine
Iodides of potash, soda and
ammonia
all other
Lactates n. s. p. f.
Lead:
Chromate
Nitrate
Oxide (litharge) with or
without gold & silver
Peroxide
Red Oxide of
Sugar of
Sulfate
all other salts n. s. p. f.
Licorice extracts
crude or refined
Medicinal
Lime:
Acetate and gray acetate
Chloride of and bleach liquors
Citrate of
Magnesia:
Carbonate, artificial
Chloride & liquors of
Manganese chloride
Medicinal and pharmaceutical
preparations, n. s. p. f.

Mercury:
Metal and alloys thereof
Chlorides
Metalloids n. s. p. f.
Methyl-ethyl Ketone
Morphine and its salts
Nickel:
Oxide
Sponge
Sulfate
Nicotine
Nicotine, salts of
Nitrates of thorium, cerium and
rare earths
Nitrates n. s. p. f.
Opium alkaloids
Organic chemicals for medicinal
use n. s. p. f.
Oxides n. s. p. f.
Peroxides
Persulfates
Phosgene
Phosphorus, red & yellow
Phosphorus hydride
Phosphorus sesquisulfide
Photographic chemicals n. s. p. f.
Potassium (or potash):
Arsenate
Carbonate
Caustic Solid or liquor
Chlorate
Chloride
Chromate and Bichromate
Magnesium sulfate
Manganate & permanganate
Nitrate
Oxalate
Phosphate
Prussiate yellow or red
(sodium)
Sulfate
Sulfide (soda)
Sulfocyanide
Salts, all other n. s. p. f.
Proprietary medicines
Quinine, its salts and compounds
Rochelle salts
Saccharine
Sallylates n. s. p. f.
Salt
Salt brines and bitterns
Santonin
Selenium sludge
Silk:
artificial
Nitro
all other
Silver:
Bromide
Chloride
Nitrate
All other salts
All other compounds
Sodium (or soda):
Acetate
Aluminate
Arsenate
Ash, crude and refined:
boiler scale preparations
containing soda ash; wash-
ing soda
Bicarbonate
Bisulfate (Nitro Cake)
Caustic solid or liquid
Chlorate
Chromate or Bichromate
Crystals (Soda)
Hydrosulfite
Hypo-sulfite
Nitrate
Nitrite
Peroxide
Phosphates
Silico-fluoride
Sulfate (Salt Cake)
Sulphydrate
Sulfide
Sulphite and bisulphite
Strontium:
Carbonate (artificial)
Chloride
Oxide
Sulfides, all other n. s. p. f.
Sulfuric acid
Sulfur, Spence metal
Sulfur chloride
Synthetic or artificial foods or
nutrients
Tartar emetic
Thorium, cerium and zirconium,
all other salts of
Tin:
Chlorides of
Oxides of
All other salts of n. s. p. f.
Tungsten dioxide
Water glass (potash or soda)
liquid
Water glass (potash or soda)
solid
Welsbach mantles, scrap
Zinc:
Chloride
Sulfate
Salts, all other n. s. p. f.
All other chemicals and pharma-
ceutical products

XVIII—DYES AND DYE WARES
Cochineal
Lac-Dye
Animal kermes, cochineal, car-
mine, sepi
Coal Tar Dyes
Aniline Dyes
Azo Dyes
Sulfur Dyes
Azuline, Fuchsine and Rosein
Dyes
Naphthalene Dyes
Anthracene Dyes other than
Alizarin red
Alizarin red
Indigo vegetable and synthetic
Indigo carmine and lakes of in-
digo and indigo carmine
Food and butter colors
Prussian blues, chrome-green
and Zinc-green
Ultramarine and ultramarine
lakes
Cobalt Oxide
XVIII—DYES AND DYE-WARES
Litharge
White lead
Blanc fixe
Zinc oxide (white)
Zinc dust
Lithopone
Zinc oxide (gray)
Red cinnabar
Copper oxide
Logwood extracts
Extracts of fustic, Brazil wood
Q uercitron & other dye woods
Chalk, white, washed, etc.
Iron oxide, native and artificial
(also yellow ochre)
Umber, sienna & other N. S.
P. F. earth colors.
Dry, not prepared printing ink
lampblack
Bronze and metal colors
Chrome colors
Copper pigments & other n. s. p.
f. pigments & lakes, dry or
pulp
Colored printing inks; cheese
colors, orseille extract, chloro-
phyl and other n. s. p. f. pre-
pared colors
Printing ink, black
Lead, zinc, lithopone, iron oxide
ground in oil, in tins or other-
wise packed for retail; all
other prepared colors.
Smalts
Colors in color boxes, water-
colors, etc.
Ink, ink-powder
Graphite, formed for retail
Zinc chromate
Lead and colored pencils or
crayons; chalk crayons
All other dyes and dye wares.
XIX—ETHERS AND ALCOHOLS
Acetic ether
Amyl ether
Butyric ether
Ethyl ether
Ethers of all kinds; cognac-oil
Fuseloids; amyl, butyl, propyl
alcohols
Crude wood alcohol
Crude acetone
Refined acetone, wood alcohol
and water solutions of formal-
dehyde
Acetaldehyde, paraldehyde
XX—VOLATILE OILS, ARTIFICIAL
PERFUMES, TOILET PREPARATIONS
Wood tar oil, caoutchouc oil,
animal oil.
Turpentine oil, pine-needle oil,
rosin spirit
Orange, lemon, bergamot and
other citrus volatile oils.
Camphor, anise, clove, laurel,
elderberry, peppermint, rose-
mary, lavender and other vo-
latile oils; menthol and
methol pencils
Terpineol, heliotropin, vanillin,
cumin, anethol, benzalde-
hyde and other perfume ma-
terials
Synthetic perfumes
Odoriferous fats, ointments
and pomades
Eau de Cologne
Other ether and alcohol contain-
ing toilet waters, vinegars
and preparations
Ether and alcohol containing
mouth and hair washes
Toilet waters
Powders, cosmetics, tooth and
n. s. p. f. powders
XXI—ARTIFICIAL FERTILIZERS
Artificial guano, ground bones
and flesh, animal manure

Natural guano
Bone-meal
Thomas phosphate meal
Superphosphates, etc.
XXII—EXPLOSIVES, AMMUNI-
TION, COMBUSTIBLES
Gut cotton, collodion cotton
Gun powder
Cordite
Dynamite and other explosives
Picric acid
High explosives
Propellants
Primers and the like; flobert
munitions
Loaded cartridges
Matches, wood and paper
Matches, wax
Fireworks; antimony, magnesi-
um or zinc torches
Pitch-torches; fuses, etc.
XXIII—WOOD FIBER, CHEMI-
CAL PAPER
Mechanical pulp
Straw, esparto and other fibers;
paper-stock
Tracing, blue-print, gelatine,
fly, ozone and test papers
Sulfate pulp
Sulfite pulp
Papier maché
Sensitized paper
Photographic paper
XXIV—FIREBRICK AND CLAY
PRODUCTS
Firebrick; rectangular under 5
Kg. per piece
Firebrick; rectangular over 5
Kg. per piece
Other fireproof materials of
clay or clay-like materials;
crucibles, muffles, capsules,
tubes, cylinders and other
hollow-ware except retorts;
plates other than stone; cruci-
bles of magnesite cement or
soapstone
Retorts
Graphite crucibles, tuyeres, etc.
Porcelain chemicalware
XXV—METALS
Fine gold; alloyed gold, crude
or cast; gold bars
Gold ashes, scrapings or broken
gold
Platinum, iridium, osmium, pal-
ladium, rhodium, ruthenium,
unalloyed crude or cast
Fine silver, alloyed silver crude
or cast; silver bars
Silver scrapings
Pig iron
Scrap steel
Scrap cast-iron
Ferro - aluminum - chrome -
manganese-nickel-silicon and
other non-malleable iron-al-
loys
Ferro-serium
Aluminum crude in plates
Aluminum bronzes
Lead, crude, lead scrap
Zinc, crude
Zinc scrap
Zinc, drawn, rolled
Tin crude and scrap
Nickel metal and coins
Copper, crude
Copper coins, scraps, etc.
Brass and similar alloys and
scrap
Bronze and similar alloys and
scrap
Yellow metal
Antimony, crude
Chrome, cadmium, tungsten
and other non-noble metals
adapted for fabrication, crude
and scrap
Copper rods, sheets, vessels
and hollow-ware
XXVI—INDUSTRIAL WASTES
Animal
Vegetable
Iron
Glass
Tobacco
Wax
Cotton
Lead
Dried Fruit
Dyehouse
Linen, hemp, jute
Caoutchouc
Nickel
Silk
Soapmakers
Wool
Sugar
Fertilizer
Papermakers
Leathers & Hides
All other

The following list, List II, contains those items in our own U. S. lists as given in "Monthly Summary of Foreign Commerce of the United States" and "Quarterly Statement of Imported Merchandise Entered for Consumption in the United States," and not contained in List I. In noting the entries of List II and the italicized entries of List I it must be remembered that not all those entries appear separately; in many cases they are separated, but in the majority of cases they are lumped in with a large number of other items, and segregation into values is not feasible and generally impossible. No practical way of indicating these two kinds of entries in the time now available has suggested itself to me, otherwise it would have been here incorporated.

LIST II	
Acetanilid	Kainite
Acetphenetidine	Keene's cement
Acid:	Kieserite
Chromic	Lakes, dry or pulp
Glycerophosphoric	Lard, neutral
Prussic	Compounds and substitutes
Pyrogallie	Licorice root
Valerianic	Linoleum
Amyl acetate	Magnesium metal
Amyl nitrite	Mantles (gas, oil, etc.)
Ammonia perchlorate	Marine glue pitch
Persulfate	Nickel alloys
Phosphate	Oil:
Anilin, arseniate	Almonds (sweet)
Antipyrine	Birch tar
Antitoxines	Cajeput
Asphaltum and bitumen	Chinese nut
Aspirin	Cinnamon
Babbitt metal	Citronella
Baking powder	Cod
Barium metal	Cod liver
Bauxite, concentrates	Eucalyptus
Beans, soya	Hempseed
Vanilla	Origanum (red and white)
Beet pulp	Poppyseed
Bismuth	Oil cake:
Blanco polish	Bean, soya
Bleachers blue	Corn
Blood, dried	Cotton seed
Calcium cyanamide	Cotton and linseed
Metal	Mustard
Tartrate	Peanut
Cam-wood	Rapeseed
Carbon electrodes	Oil cake meal
Cellophane	Oil cloths
Cerium, ore	Oleostearine
Chalk, purified	Orange mineral
Chemical pulp:	Pewter
Bleached	Phenolphthalein
Unbleached	Photographic, dry plates
Chocolate	Films
Cobalt	Potassium, bitartrate
Cobalt, ore	Metal
Cobalt, oxide	Printing ink
Cocoa, crude	Pulp-wood.
Corundum	Rough
Culm	Peeled
Dead oils	Rosseed
Earth, Van Dyke	Radium and its salts
Earthenware:	Rhodium
Vitreified	Ruthenium
Non-vitreified	Salicine
Ecgonine	Salol
Ether, nitrous	Santonine
Extract, meat	Saponine
Persian berries	Selenium and salts
Ferro-molybdenum	Sheep-dip
Ferro-phosphorus	Seed:
Ferro-titanium	Hemp
Ferro-tungsten	Sugar beet
Ferro-vanadium	Soap:
Filter-tubes	Castile
Fulminates	Medicinal
Galalith	Toilet, perfumed
Gas liquor	Toilet, unperfumed
Gelatine	Sodium, metal
Glucose (syrup)	Strychnine and its salts
Glue	Sugar (cane & beet) tank bot-
Glue size	toms, syrups, etc., up to 100°
Grease, enfleurage	Sugar, grape
Soluble	Sugar, beets
Guaiacol carbonate	Sugar, maple (and syrup)
Gum, chicle	Tantalum
Guayule	Terpene hydrate
Gypsum cements	Thymol
Incandescent lamps	Titanium
Carbon-flament	Type-metal
Metal-flament	Uranium, oxide
Insulating compound	Urea
Iron chromate	Washing powder & fluid
Ivory, vegetable	Zinc, dust
	Sulfide

In working with List I above, it must be borne in mind that in few cases only has any alphabetical arrangement been attempted for the reason that in the original lists little or no regard to alphabetical arrangement is had; the items seem to be arranged according to some commercial connection, real or assumed, be-

tween the various items. Further, that extreme niceties as to logic of classification cannot be considered by those who, in the final event, must gather the information; that repetition *must* be avoided, and no material can be reported more than once. Those who use the lists in their final form must be prepared to perform some mental labor in spelling out from such records the precise information they may want in any specific instance.

All of the foregoing lists are based upon official documents (except U. S.) published before the outbreak of the present war.

On May 10, 1916, the British government prohibited the exportation of a number of chemical substances from Great Britain. This list appeared in the May 31, 1916, issue of the *Journal of the Society of Chemical Industry*, pages 620-622. It is more diversified than any single government commerce report that I have found; it may give valuable hints as to those things that in time of stress assume an importance to a nation's life that is not accorded them in times of peace; since such list may foreshadow further expansion of commerce reports, such parts as are not contained in the foregoing are now given as List III. Study of this list may very well suggest proper additions to our own commerce or similar reports.

LIST III	
Aeroplane dope	Henbane and its preparations
Capsicum	Hexamethylene tetramine and its preparations
Capsicum-Oleo-Resin	Hydrobromic acid
Carbon, Brazilian	Hydroquinone and mixtures containing it
Aluminum nitrate	Ipecacuanha root
Amidol and mixtures containing it	Manganese peroxide
Ammonia sulfocyanide	Methylaniline
Anti-tetanus serum	Methyl salicylate and its preparations
Belladonna and its preparations	Metol and mixtures containing it
Belladonna alkaloids, their salts and preparations	Naphthalene compounds and preparations
Bismuth nitrate	Neosalvarsan
Calcium sulphide	Nitrotoluol
Cantharides	Novocain and its preparations
Chromium chlorate	Nux Vomica and its preparations
Chromium nitrate	Radium compounds
Cobalt nitrate	Salipyrine
Copper suboxide and mixtures containing it	Salvarsan
Cresol and nitrocresol	Senna leaves
Cyanamide	Stramonium leaves and seeds
Diethyl barbituric acid (Veronal)	Sulphonol
Dyes, coaltar, all articles containing them	Theobromine-sodium salicylate
Emetine and its salts	Triphenyl phosphate
Ergot of rye	Trional
Ether formic	Trioxymethylene
Gentian preparations	Xylol and its preparations and compounds
Green oil	Scheelite
Halogen derivatives of aliphatic hydrocarbons	Selenium
	Vanadium
	Mineral jellies

The tariff act of the U. S. recites certain specific chemicals and also classes of chemicals, and these may also suggest proper additions; some of the relevant entries in the tariff act of Oct. 3, 1913, are given in List IV. The Treasury Department makes returns under each of the heads of List IV, and this information might be kept separate and published, or at any rate so much of it as may thus serve a useful purpose; it is to this point that special attention should be directed, since it promises the easiest and most practicable mode of expansion for all concerned.

LIST IV	
Acids:	Salicylic
Acetic	Silicic
Arsenic	Sulfuric
Arsenious	Tannic and Tannin
Boric	Tartaric
Carbolic	Valerianic
Chromic	Acetic anhydride
Citric	Acetine
Fluoric	Alcohol, wood
Formic	Alkalies, alkaloids and medicinal mixtures
Gallic	Alumina hydrate
Hydrochloric	Alum
Hydrofluoric	Alum cake
Lactic	Patent alum
Nitric	Sulfite of alumina
Oxalic	Aluminous cake
Phosphoric	Ammonia carbonate
Phthalic	Ammonia muriate
Prussic	Ammonia liquid anhydrous
Pyrogallie	Ammonia sulfate

Ammonia nitrate	Sperm	Bichromate	Cod liver
Ammonia perchlorate	Wool grease	Yellow prussiate	Cotton seed
Apatite	Turkey red	Borate (borax)	Croton
Argols	Linseed	Carbonate	Ichthyol
Crude tartar	Poppy seed	Salt	Juglandium
Cream tartar	Rape seed	Sulfite crystals	Palm
Rochelle salts	Peanut	Talcum	Palm kernel
Calcium tartrate	Hempseed	Ground talc	Perilla
Balsams:	Almond, sweet	Stearite	Soya bean
Copaiba	Sesame	French chalk	Olive oil
Fir	Bean	Vanillin	Chinese nut
Canada	Olive	Vanilla beans	Nut
Peru	Orange	Tonka beans	Kerosene
Tolu	Lemon	Arsenic	Benzine
Barium chloride	Peppermint	Sulfide of arsenic	Naphtha
Dioxide	Almond, bitter	Cinchona bark	Gasoline
Carbonate, precipitated	Amber	Bauxite	Paraffine
Blackening, polishing powders and creams	Ambergris	Beeswax	Spermacetti
Bleaching powder	Anise	Bismuth	Whale
Caffein	Bergamot	Copper sulfate	Oleo-stearin
Calomel	Camomile	Acetate	Orchil
Corrosive sublimate	Caraway	Sub-acetate	Ores of gold
Chalk, precipitated	Cassia	Bone dust	Silver
Chloral hydrate	Cinnamon	Meal	Nickel
Solol	Cedrat	Ash	Platinum
Phenolphthalein	Citronella	Crude	Paris Green
Urea	Lemongrass	Borates of soda, crude	London Purple
Terpin hydrate	Civet	Lime, crude	Phosphates, crude
Acetanilid	Fennel	Civet	Phosphorus
Acetphenetidine	Jasmine	Cadmium	Photographic films
Antipyrine	Juniper	Calcium acetate, brown or gray	Platinum metal and manufactures of
Glycero-phosphoric acid	Lavender	Calcium chloride, crude	Plumbago
Acetylsalicylic acid	Aspic	Calcium carbide	Potash:
Aspirin	Limes	Calcium nitrate	Crude or black salts
Guaiacol carbonate	Neroli	Cement, Roman, Portland and other hydraulic	Carbonate
Thymol	Origanum (red and white)	Cerium ore	Sulfate
Chloroform	Thyme	Chromate of iron	Hydrate
Carbon tetrachloride	Valerian	Chromium, hydroxide, crude	Nitrate
Benzol	Morphine sulfate	Anthracene	Muriate
Naphthol	All other opium alkaloids	Anthracene oil	Quinine Sulfate and all cinchona alkaloids
Resorcin	Cocaine	Naphthalene	Radium and its compounds
Toluol	Egonine	Phenol	Selenium and its salts
Xylol	Barytes	Cresol	Salt
Toluidin	Blanc fixe	Cobalt and ore	Santonin
Nylidin	Satin white	Cochineal	Sheep dip
Cumidin	Blues:	Sulfate of iron	Soda arsenate
Binotrobenzol	Prussian	Cryolite	Cyanide
Binotrotoluol	Berlin	Cudbear	Sulfate (salt cake)
Benzidin	Chinese	Dividivi	Bi-sulfate (niter cake)
Tolidin	Ultramarine	Fulminates	Ash
Dianisidin	Black:	Gambier	Silicate
Naphthylamin	Bone	Greases and fats for soap making	Nitrate
Diphenylamin	Ivory	Guano	Soya beans
Benzaldehyde	Vegetable	Basic slags	Strontium oxide
Benzylchloride	Gas	Cyanamide	Carbonate
Nitrobenzol	Lamp	Lime-nitrogen	Strychnine and its salts
Nitrotoluol	Chrome:	Gunpowder and all explosives	Sulphur
Naphthylamin sulfo acids	Yellow	Gutta percha	Pyrites
Naphthol sulfo acids	Green	India rubber, crude, scrap and refuse	Talcum, steatite, French chalk
Amidosalicylic acid	Ochre	Indigo	Tanning extracts:
Binotrochlorbenzol	Sienna	Iodine	Quebracho
Diamidostilbendi sulfo acid	Umber	Iridium, osmium, palladium, rhodium and ruthenium	Hemlock Bark
Metanilic acid	Spanish brown	Iron ore	Oak
Paranitronilin	Venetian red	Kieserite	Chestnut
Dimethylaminlin	Indian red	Kalnit	Nuts
Colbalt, oxide of	Colcothar	Casein	Nutgalls
Colloidion	Litharge	Lard	Terra alba
Ethers:	Orange, mineral	Asphalt, bitumen	Tin ore and metal
Sulfuric	Red lead	Litmus	Tungsten ores
Amyl nitrite	White lead	Madder	Turpentine, Venice and spirits
Amyl acetate	Lead acetate	Magnesite	Uranium oxides and salts
Ethyl acetate	Lead nitrate	Manganese, oxide and ore of	Valonia
Ethyl chloride	Varnishes	Myrobolans	Wax, vegetable or mineral
All other ethers and esters	Vermillions	Oils:	Witherite
Extracts of:	Whiting and Paris white	Birch tar	Woodpulp:
Nutgalls	Zinc oxide	Cajeput	Mechanical
Persian berries	Lithopone	Cocanut	Chemical
Sumac	Zinc sulfide (white)	Cod	Bleached
Logwood	Zinc chloride		Unbleached
Chlorophyll	Zinc sulfate		Matches
Saffron	Enamel paints		
Safflower	Paints		
Formaldehyde	Colors		
Fusel oil	Stains		
Amylic alcohol	Pigments		
Gelatine	Crayons		
Glue	Smalts		
Glue-size	Ceramic fluxes		
Isinglass	Glass fluxes		
Agar-agar	Potash:		
Glycerine, crude	Bicarbonate		
Glycerine, refined	Chlorate		
Gum:	Chromate		
Amber	Bichromate		
Arabic	Nitrate		
Senegal	Permanganate		
Camphor, crude	Red prussiate		
Camphor, refined or synthetic	Yellow prussiate		
Chicle, crude	Salts of bismuth		
Dextrine	Gold		
Burnt starch	Platinum		
British gum	Rhodium		
Ink and ink powders	Silver		
Iodoform	Tin		
Potassium iodide	Soaps, perfumed, toilet		
Licorice extracts	Medicinal		
Licorice root	Castile		
Cocoa leaves	All other		
Lime citrate	Soda:		
Magnesia calcined	Benzoate		
Magnesia carbonate of	Chlorate		
Magnesia sulfate (Epsom salts)	Nitrate		
Menthol	Bicarbonate		
Oil:	Caustic		
Cod	Phosphate		
Seal	Hyposulfite		
Herring	Sulfide		
Whale	Sulfite		
	Chromate		

The labor expended in getting up the foregoing lists has been considerable, and it has been exceedingly tiring work; it has resulted in bringing into relatively small compass information contained in four different languages, and itself widely scattered; in spite of reasonable care, I have no doubt overlooked some items and duplication may not have been completely avoided, but this should in no wise deter everyone interested from taking off his coat and getting down to work to see, firstly, if he himself and his interests are supplied with proper information and, if not, just what further information may be needed; then repeat that process for his section of the country, and then for the country at large, and forward that information in a letter (preferably typewritten) to the secretary of the nearest section of the American Chemical Society or American Electrochemical Society.

Such letters should be written on paper of the ordinary business letter size, say 8 or 8½ by 11 in., and on one side of the paper only. The intention is to have these original letters suitably bound and appropriately

indexed, and to have them accompany the final recommendation when and if it is presented to the officials in Washington. The work of the members of the local sections of the chemical societies and of this special committee will be greatly expedited if each such letter were to be accompanied by seven carbon copies to serve as working copies for the various committee members, and such effective co-operation will be more than repaid in speed and certainty.

The final recommendation of this special committee must be backed up, so far as possible, by individual letters, otherwise those recommendations might very properly be looked upon as the personal opinions of only a few; that would not be fatal, but it would be disadvantageous.

This special committee itself cannot possibly bring this plan to the attention of all interested; it must depend upon the co-operation of the members of the national chemical societies to bring this matter to the attention of local boards of trade, chambers of commerce or similar co-operative business organizations, and to the attention of individual concerns and corporations. Each member has his work to do, and this special committee counts with entire confidence upon a full performance.

Persons and corporations not members of a chemical society need feel no hesitancy whatever in taking active part in this work; write your suggestions to the secretary of the section of the A. C. S. or A. E. S. nearest to you. There are no formalities and there is no need to stand on ceremony.

With 55 centers of information-gathering located in 32 states of the Union and the District of Columbia a substantial consensus of opinion should be obtainable.

In addition to the foregoing list helpful suggestions may be obtained by consulting the weekly import and export lists that appear in the *Oil, Paint and Drug Reporter* of New York, and the daily lists of manifests of incoming steamers as they appear in the *Journal of Commerce and Commercial Bulletin* of New York; also the weekly and annual summaries of British foreign and domestic chemical trade as they appear in *The Chemical Trade Journal* may offer useful suggestions.

List V gives the name and address of the secretary of each local section of the A. C. S. and of the A. E. S., arranged alphabetically by States.

LIST V

LOCAL SECTIONS, A. C. S.

- Alabama:**
W. H. Beers, Jr., 2114 First Avenue, Birmingham, Ala.
- California:**
B. S. Drake, 5830 Colby Street, Oakland, Cal.
Henry L. Payne, 223 West First Street, Los Angeles, Cal.
- Connecticut:**
F. J. Marsh, c/o R. Wallace & Sons Mfg. Co., Wallingford, Conn.
- Dist. of Columbia:**
G. S. Jamieson, 121 Linden Street, New Haven, Conn.
- Georgia:**
J. S. Brogdon, 70½ Peachtree Street, Atlanta, Ga.
- Idaho:**
H. A. Holaday, University of Idaho, Moscow, Idaho.
- Illinois:**
D. K. French, 2005 McCormick Bldg., Chicago, Ill.
Geo. D. Beal, 208 Chemistry Bldg., University of Illinois, Urbana, Ill.
- Indiana:**
H. W. Rhodehamel, 643 East Thirty-second Street, Indianapolis, Ind.
- Iowa:**
W. G. Graessler, Iowa State College, Ames, Iowa.
Perry A. Bond, Cedar Falls, Iowa.
- Kansas:**
W. B. Smith, 24 Federal Building, Kansas City, Kansas.
- Kentucky:**
P. L. Blumenthal, Agricultural Experiment Station, Lexington, Ky.
A. M. Breckler, c/o Janes & Breckler, Louisville, Ky.
- Louisiana:**
F. W. Liepsner, 310 Custom House, New Orleans, La.
- Maine:**
L. M. Burghart, University of Maine, Orono, Me.
- Maryland:**
F. M. Boyles, c/o McCormick & Co., Baltimore, Md.
- Massachusetts:**
E. B. Spear, Mass. Inst. Tech., Boston, Mass.

Michigan:

James H. Bogart, 925 Y. M. C. A. Bldg., Detroit, Mich.
H. H. Willard, 802 Monroe Street, Ann Arbor, Mich.

Minnesota:

Sterling N. Temple, 1758 West Blair Street, St. Paul, Minn.

Missouri:

George Lang, Jr., 3601 Salena Street, St. Louis, Mo.
Albert G. Loomis, 518 College Avenue, Columbia, Mo.

Nebraska:

H. M. Plum, Dept. Agr. Chem., Lincoln, Neb.

New York:

J. A. Bridgman, Morse Hall, Ithaca, N. Y.
C. F. Roth, 52 East Forty-first Street, New York City.
Ray H. White, 730 Buffalo Avenue, Niagara Falls, N. Y.
H. H. Tozier, 26 Jones Avenue, Rochester, N. Y.
A. J. Salathe, Union College, Schenectady, N. Y.
R. S. Bochner, Bowne Hall, Syracuse University, Syracuse, N. Y.

North Carolina:

F. E. Carruth, West Raleigh, N. C.

Ohio:

E. K. Files, Univ. of Cincinnati, Cincinnati, Ohio.
A. F. O. Germann, Adelbert College, Cleveland, Ohio.
W. J. McCaughey, O. S. U., Columbus, Ohio.

Oregon:

Norman C. Thorne, 841 Brooklyn Street, Portland, Ore.

Pennsylvania:

Geo. C. Beck, 325 Wyandotte Street, South Bethlehem, Pa.
J. H. Graham, 113 West Manheim Street, Germantown, Pa.
W. C. Cope, U. S. Bureau of Mines, Pittsburgh, Pa.

Rhode Island:

Robt. F. Chambers, Brown University, Providence, R. I.

South Carolina:

A. C. Summers, University of South Carolina, Columbia, S. C.

South Dakota:

H. I. Jones, Dakota Wesleyan, Mitchell, So. Dak.

Tennessee:

Paul C. Bowers, 9 Garland Avenue, Nashville, Tenn.

Vermont:

C. E. Burke, Burlington, Vt.

Virginia:

W. A. Burrows, 1000 East Carey Street, Richmond, Va.

Washington:

H. L. Trumbull, University of Washington, Seattle, Wash.

Wisconsin:

H. T. McAllister, 404 Alhambra Bldg., Milwaukee, Wis.
L. F. Augspurger, Chemistry Building, Madison, Wis.

LOCAL SECTIONS, A. E. S.

New York:

A. T. Hinckley, 548 Fifth Street, Niagara Falls, N. Y.
J. M. Muir, 239 West Thirty-ninth Street, New York City.

Pennsylvania:

S. S. Sadtler, 210 South Thirteenth Street, Philadelphia, Pa.
H. C. Ray, University of Pittsburgh, Pittsburgh, Pa.

Wisconsin:

O. P. Watts, University of Wisconsin, Madison, Wis.

Should there be any changes in local secretaries from the list above given, the person addressed as above can be confidently counted on to forward such communication to his successor.

The present plan is for this special committee to begin its preliminary list Nov. 1, 1916, complete it Nov. 15, 1916, publish this provisional list in the *METALLURGICAL AND CHEMICAL ENGINEERING* Dec. 1, and *Journal of Industrial and Engineering Chemistry*, Dec. 6, 1916, begin its final draft Feb. 14, 1917, close the final recommendations Feb. 28, 1917, and present its recommendations to the proper authorities in Washington before March 15, 1917; this will leave three and one-half months for Washington to make its decision and arrange for the gathering of the added information, if any, decided upon with the beginning of the fiscal year 1917-1918.

Delay or failure in getting suggestions to the local sections will hamper the special committee. Points of view cannot be considered unless communicated. Everybody's co-operation is not only necessary, but most cordially invited. If our list is not the best in the world to-day we must strive to make it so.

25 Broad Street,
New York City.

Fire-Resisting Materials—The Bureau of Standards, Department of Commerce, in connection with a general study of fire-resisting materials, is considering among other phases of the subject the development of a fire-resisting material for use in constructing, in whole or in part, the deck structures of excursion and passenger steamers. So far as may be applicable, the material when developed would also be considered in relation with other marine uses. The Bureau of Standards would be glad to receive from manufacturers samples of such materials as they consider suitable for the purpose, in order that they may be given consideration.

An Investigation Dealing with the Occurrence of Alumina Inclusions in Steel

BY ALBERT SAUVEUR

NATURE OF INCLUSIONS IN STEEL

By the term "inclusions" (or "enclosures"), the steel metallurgist refers to small particles of non-metallic and generally oxidized impurities mechanically held by steel after it has completely solidified. These inclusions are as a rule lighter than the metal in which they are imprisoned, and if the latter could be kept liquid for a sufficient length of time after their formation most, if not all, of these foreign particles would rise to the top of the ingot or casting. Owing to the very small size of some of them, however, and to conditions of manufacture, a small amount of these inclusions must of necessity be retained in the solidified metal.

The inclusions commonly described comprise silicates, chiefly of manganese and of iron (frequently called "slag"), and manganese sulphide (often associated with iron sulphide). The use of titanium as a deoxidizer may introduce some titanium nitride inclusions, while the use of aluminium for the same purpose may result in the formation of alumina inclusions through the oxidation of some of the aluminium.

PURPOSE OF THE INVESTIGATION

The present investigation was undertaken for the purpose of ascertaining whether the occurrence of alumina inclusions in steel could be detected under the microscope and of studying the characteristics by which these inclusions can be distinguished from other inclusions.

PAST LITERATURE

Barring one or two unimportant exceptions, I am unable to find in the literature dealing with inclusions any reference to the occurrence of alumina antedating Mr. Comstock's article presently to be described. Previous to his writing, alumina had not generally been considered as a distinct or, at least, as a distinguishable inclusion.

Referring to the use of aluminium as a deoxidizer, however, and to the resulting formation of alumina, Rosenhain¹ writes:

"A more powerful deoxidizing agent than manganese is furnished by aluminum, but this differs from manganese in two vitally important respects. In the first place, the oxidation product of aluminum is a particularly refractory substance—alumina—which has a strong tendency to remain in the molten metal in suspension as fine particles."

In a paper entitled "The Solid Non-Metallic Impurities in Steel," the author, Mr. Henry D. Hibbard, writes:

"If other elements have been added, such as Al, W, Cr, Ti, or V, their oxides and silicates may be present.

"The too plentiful use of Al in steel may have been condemned, partly at least, because it forms oxides or silicates in the metal, which, being insoluble and infusible, exist in the solid steel as very harmful sonims. Of course, to form the oxide there must still be some oxide of iron or manganese in the steel. If the metal were free from O perhaps the weakening effect of Al when added in greater quantity than a few hundredths of 1 per cent would not occur. So a part of the Al added in the ladle would form sonims which might be fluxed and floated out, while that added in the molds, if the steel were free from O, would not be oxidized, but would all be left to exercise its full effect in preventing the formation of gas-bubbles and the resulting blow-holes in the steel."

MR. GEORGE F. COMSTOCK ON ALUMINA IN STEEL

In an article entitled "A Study of Alumina in Steel,"

¹An Introduction to the Study of Physical Metallurgy, Walter Rosenhain, page 153.

²Transactions of American Institute of Mining Engineers, Vol. XLI, pages 803-822.

published in METALLURGICAL AND CHEMICAL ENGINEERING for Dec. 1, 1915, Mr. George F. Comstock describes the occurrence and appearance of alumina inclusions in steel. Referring to alumina inclusions, Mr. Comstock writes:

"These inclusions are in the form of small rounded spots, arranged close together in one elongated streak. They are of a very dark bluish-gray color, when examined with the white light of an electric arc, appearing black unless highly magnified, and it is practically impossible to polish them without forming little pits around each inclusion. If the polishing is done very carefully, these pits may be kept very small; but with certain methods of polishing the pits are made so large that the original inclusions cannot be seen at all.

"If the specimen is not rotated constantly during the final polishing, the pits take the form of short scratches, and each inclusion will have a little tail, like a comet. It will be noticed in Fig. 1 that although this shows a longitudinal view of a bar, the individual inclusions have not been elongated by the forging at all, but merely the group as a whole has been drawn out into a streak.

"The difference between inclusions of alumina and ordinary slag or silicates in steel may then be summarized as follows:

"(1) Silicate inclusions will generally take a fairly smooth polish in a section prepared for microscopic examination, while alumina is very hard to polish without pitting. (2) Silicate inclusions are always elongated in the direction of rolling or forging, while alumina particles are not (the groups of particles are, of course elongated but not the particles themselves). (3) Silicate inclusions are often found of quite large size (as well as very small), while particles of alumina are always small, and do not seem to coalesce into large bodies even when closely grouped together. These characteristics of alumina inclusions agree with what is known of the properties of alumina. Its great hardness and brittleness would account for the pitting effect; its infusibility would account for the small size of the particles and the tendency not to coalesce; and both of these properties together would account for the particles not being elongated by forging or rolling of the steel in which they were embedded.

"All samples in which more than the merest trace of alumina was found by analysis were seen to contain the typical inclusions as described above, and those in which alumina was not found by analysis, did not contain these inclusions. Furthermore, those in which more alumina was found by analysis contained more of these inclusions than those in which only a very little was found. These facts have been considered as a good confirmation of the theory that the typical small inclusions, as described above, found in so many commercial steels, are chiefly, if not wholly, alumina."

INVESTIGATION

As a preliminary step I took photomicrographs at a magnification of 300 diameters of five samples that Mr. Comstock used in his work, and a comparison of these photomicrographs with those taken by him showed that both sets were very similar and that they confirmed Mr. Comstock's description of the appearance of the inclusions.

In Fig. 1 is shown under a magnification of 300 diameters the appearance of the longitudinal section of a bar forged from a steel ingot to which 0.144 per cent aluminium had been added during the teeming from the ladle to the molds. The steel was made at the Watertown Arsenal, Watertown, Mass., in a Tropenas converter. Both ferro-manganese and ferro-silicon were used in recarburizing and deoxidizing. The inclusions shown in the photomicrograph present the characteristics described by Mr. Comstock as pertaining to alumina inclusions, namely, small dimensions of the individual particles, dark coloration, string formation in the direction of the forging, but non-elongation of the particles themselves.

Attempts were made as follows to produce molten iron under such conditions as to preclude the occurrence in the solidified metal of any inclusions but alumina:

1. Thermit iron produced with an excess of aluminium.

2. Ingot iron melted with aluminium.

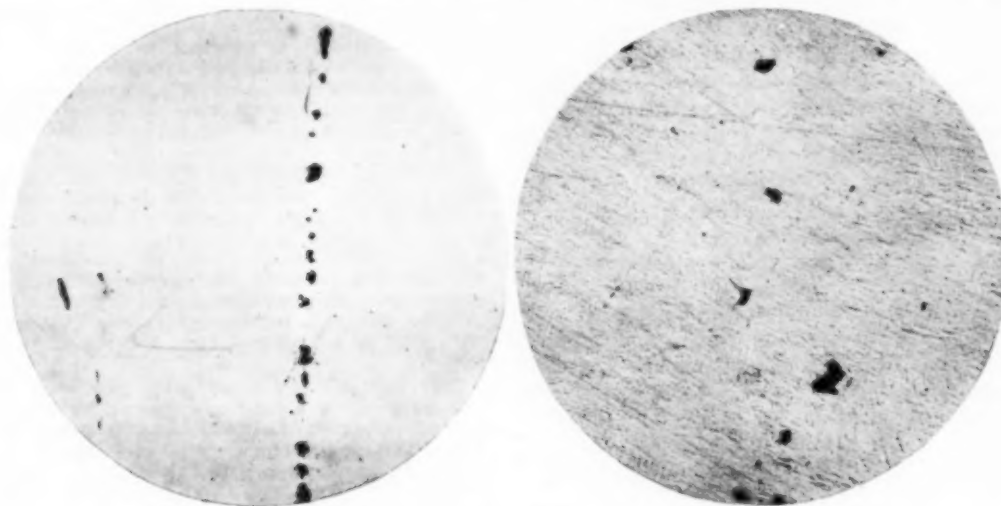
3. Ingot iron melted with alumina.

The results obtained will be briefly described.

Thermit Iron.—A small mass of thermit iron was produced in the usual way in a graphite crucible with

the absence of elongation in the direction of the forging.

Ingot Iron Melted with Aluminium.—A small amount of ingot iron was melted in an alundum crucible with the addition of aluminium. The expectation was that enough oxygen would be present to cause the oxidation of some aluminium and, therefore, the occurrence of alumina inclusions to the exclusion of all other inclu-



FIGS. 1 AND 2—MICROPHOTOGRAPHS

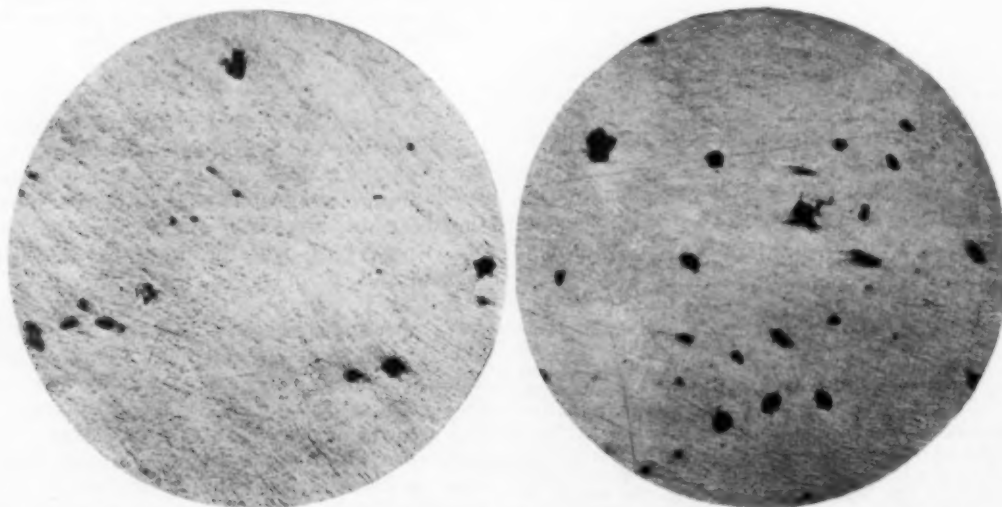
the addition of a small amount of finely powdered aluminium to the thermit mixture as commercially supplied. The small ingot was forged into a bar about $\frac{1}{4} \times \frac{1}{4}$ in. in cross-section.

It is believed that the thermit mixture practically consists of pure iron oxide and pure aluminium, and that any inclusions present must of necessity be alumina resulting from the oxidation of some aluminium.

A longitudinal section of the forged bar was prepared for microscopical examination and the polished but unetched surface photographed under a magnification of 300 diameters (Fig. 2). It will be seen to contain many small, dark and roughly rounded particles scattered

sions. The resulting mass was forged into a bar measuring about $\frac{1}{4} \times \frac{1}{4}$ in. in cross-section. A longitudinal section of the bar was polished and photographed under a magnification of 300 diameters. The presence of a number of small dark particles was clearly revealed (Fig. 3). They exhibit the characteristics previously described as pertaining to alumina inclusions, being small in size, dark in color, and non-elongated in the direction of the forging.

Ingot Iron Melted with Alumina.—Some ingot iron was melted in an alundum crucible with finely powdered alumina. It was assumed that while most of the alumina might float to the top of the molten bath, some of the



FIGS. 3 AND 4—MICROPHOTOGRAPHS

through the iron. It should also be noted that there is no indication whatever of these inclusions having been elongated by the forging. Although they do not occur in clusters or in strings, they present the chief features described by Mr. Comstock as characteristic of alumina inclusions, the most significant of which is

finest particles at least would be retained in the solidified metal as alumina inclusions. The small ingot was forged into a bar $\frac{1}{4} \times \frac{1}{4}$ in. in cross-section, and the appearance of a longitudinal section polished and magnified 300 diameters is shown in Fig. 4. Here again we note the occurrence of small dark inclusions scattered

through the mass and devoid of any tendency to elongate in the direction of the forging.

SUMMARY

From the results published by Mr. Comstock and confirmed by my examination of some of his samples, and from the results obtained in my own experiments as reported in the foregoing pages, it seems justifiable to conclude that alumina inclusions may be distinguished under the microscope from the other inclusions generally occurring in steel, being characterized by their small size, their dark coloration, and more especially by a complete absence of elongation in the direction of the rolling or forging.

Harvard University, Cambridge, Mass.

Synthesis of Tartaric Acid

The synthesis of tartaric acid is the subject of a patent of Dr. L. H. Baekeland and Arnold H. Peter (U. S. Patent 1,190,845, July 11, 1916). The process which is shown diagrammatically in Fig. 1 involves seven reactions marked respectively A, B, C, D, E, F, G. We quote the following description of the process from the patent specification.

(A) Carbon in any form, for instance, coke or charcoal, is introduced into a chamber or vessel provided with heating means. Into this vessel is conducted a colorless mixture of chlorin (which may be obtained later on in the process from reaction described in B or D or E or all of them) and water, preferably in the form of steam. When this mixture is conducted over the carbon heated to about 300 deg. C., there results hydrochloric acid and carbon monoxid or carbon dioxid or a mixture of the two carbon oxides. In ordinary practice, a mixture of the two oxides will result, it being usually not worth while to attempt to confine the production exclusively to either one. The hydrochloric acid thus obtained may be used in some of the reactions herein-after described either to promote said reactions or recover chlorid from their results, or both. The carbon-oxides may be used in making formates, as hereinafter described in B. Commercial requirements will determine whether both the acid and the carbon-oxides shall be used in succeeding reactions or one of them disposed of otherwise.

(B) From the carbon-oxides formate may be obtained in a variety of ways. For example, the mixture of carbon monoxid and carbon dioxid may be conducted over carbon heated to about red heat, reducing the carbon dioxid in the mixture to carbon monoxid, and the carbon monoxid may be conducted over an alkali (such, for example, as caustic soda, caustic potash, or others) heated to, say, 180 deg. to 220 deg. C., giving a formate. Or the carbon dioxid may be reduced to formate in a way which in itself affords an illustration of the process of the present invention.

Thus, water in a reaction chamber may be saturated with carbon dioxid (or the mixture of carbon-oxides containing it) and an amalgam, preferably produced by the electrolysis of a chlorid, may be caused to travel into such chamber, where it liberates hydrogen, reducing carbon dioxid to formate.

It will be observed that when this method is followed the reactions embrace the electrolysis of a chlorid, giving chlorin and a reducing agent, the utilization of the chlorin to assist in oxidizing a substance and the reduction of the oxidized substance by the reducing agent.

The hydrochloric acid resulting from the use of the chlorin with water (in the form of steam) to oxidize the carbon may be used to attack the amalgam, throw off the hydrogen from it for the reduction of the carbon dioxid and unite with the amalgam to form chlorid.

It may under some circumstances be desirable to use this cycle of chlorid, chlorin and amalgam, hydrochloric acid from chlorin, decomposing the amalgam to form chlorid and give off hydrogen, to reduce carbon dioxid obtained elsewhere.

For example, it may be, under certain circumstances, desirable to make the chlorin react upon the carbon in the presence of water or steam so as to produce hydrochloric acid and carbon monoxid almost exclusively (which may be made in this manner of exceptional purity) and dispose of the carbon monoxid, ob-

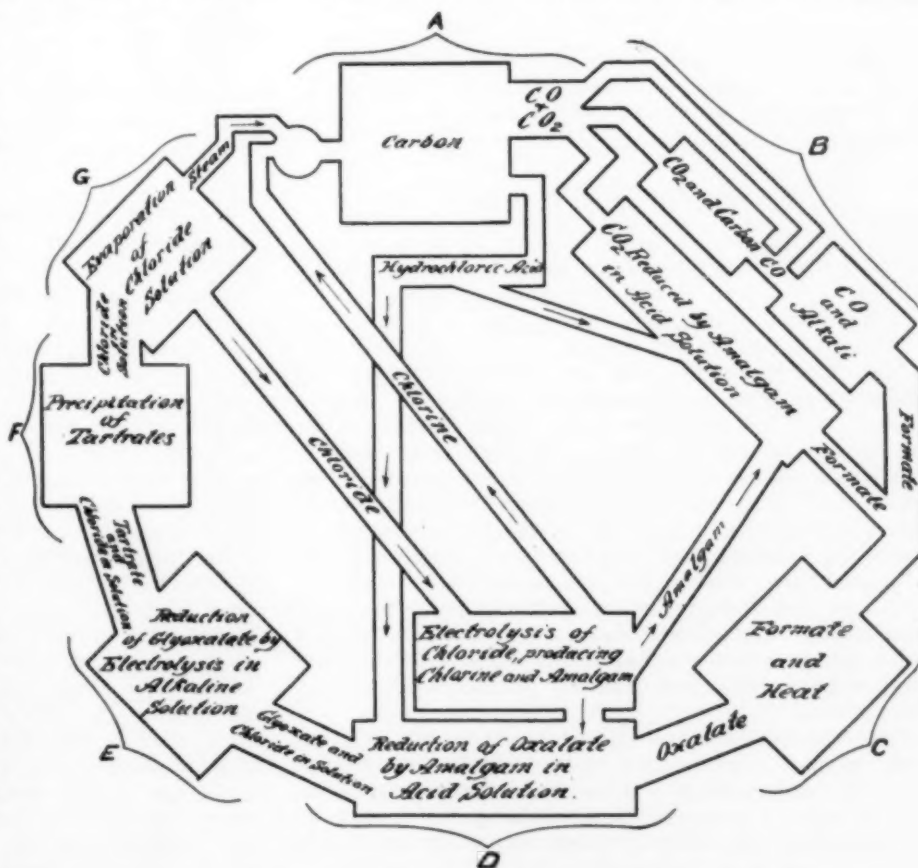


FIG. 1—SYNTHESIS OF TARTARIC ACID

taining the carbon dioxid to be reduced from some source not connected with the process.

The foregoing description of the reactions which have been designated B represents various ways of treating the substance oxidized with the assistance of the chlorin obtained from the chlorid or an equivalent substance so as to obtain formate. Any convenient way may be used. The further treatment of the oxidized product may be as follows:

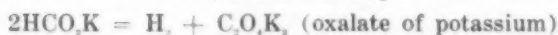
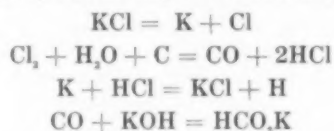
(C) The formate may be transferred into oxalate in any convenient way, as by heating the formate to, say, 360 deg. to 440 deg. C., under pressure.

(D) The oxalate may be reduced to glyoxylate by means of an amalgam, preferably in an acid solution. This amalgam may be made by the electrolysis of a chlorid, preferably potassium chlorid, generating chlorin at the anode, which may be mixed with steam and conducted over carbon, as hereinbefore described in A.

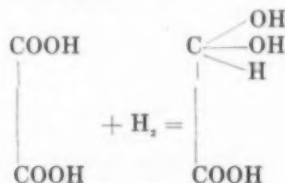
The amalgam thus produced may be caused to travel into a reaction chamber containing the oxalate and an excess of hydrochloric acid which has been obtained by conducting the mixture of chlorin and steam over carbon, as hereinbefore described in A.

The amalgam, being attacked by the acid in this reaction chamber, gives off hydrogen, reducing the oxalate to glyoxylate, and, after giving off this hydrogen, combines with the hydrochloric acid to form chlorid, which remains in solution and may either be recovered at this point and again electrolyzed or allowed to pass with the glyoxylate into and through the transformation of the glyoxylate into tartrate, as hereinafter set forth.

It will be observed that the reactions described form a complete cycle, which may be summed up as follows:



Oxalate of sodium in presence of an acid gives oxalic acid. The latter in presence of potassium amalgam and a strong acid gives glyoxylic acid:



(E) The glyoxylate may be introduced in solution rendered alkaline into the cathode chamber of an electrolytic cell, the electrolyte in the anode chamber being preferably an alkali chlorid, although other soluble chlorids, even chlorid of hydrogen, may be used. When the current is caused to pass through the solution from the anode to the cathode the glyoxylate is reduced to tartrates (racemic and meso-tartrates), which are precipitated, used and worked up, as may be desired.

If, as above suggested, the chlorid resulting from the reaction D has been allowed to remain in solution with the glyoxylate, it may be recovered after the tartrates have been precipitated, as, for example, by evaporation.

The chlorin developed on the anode in this reaction may be used in accomplishing the oxidation of the carbon, the carbon-oxids being used to produce formates, which may be converted into oxalates, which may be converted into glyoxylates, which may be converted into tartrates, as above indicated.

The alkali formed in the cathode compartment may be neutralized by the hydrochloric acid formed from the chlorin generated in the anode compartment.

The apparatus availed of in the process and in the various reactions will differ according to the particular circumstances of manufacture. In commercial practice, it will often be desirable, for example, to store temporarily the products of the various reactions, as, for instance, the formate or oxalate or acid or chlorid, before using them, or to connect the various sources of

chlorin so that the making of the hydrochloric acid or the oxidation or both may be conveniently accomplished.

The process contemplates that variations will be made in it according to commercial requirements. Thus, for example, in certain manufactures some of the reactions hereinbefore described may be omitted and the substances developed by such reactions obtained and introduced otherwise. For instance, a chlorid may be electrolyzed to develop amalgam and chlorin, the chlorin being used with steam and carbon to give hydrochloric acid and the acid used to liberate hydrogen from the amalgam and unite with the rest of it into chlorid, but instead of using the carbon-oxids (which may be obtained in connection with the making of the acid) through reactions producing therefrom oxalates or oxalic acid, the carbon-oxids may be disposed of otherwise and oxalic acid elsewhere obtained and introduced.

The invention has been described as embodied in a synthetic process for the manufacture of tartaric acids and their compounds from carbon, and it is pointed out that it is applicable also in the manufacture of certain compounds produced therein, as formates and glyoxylates. It is to be understood that it is applicable also in other synthetic processes.

It is particularly to be observed that in the specific embodiment of the invention applied to the manufacture of tartaric acids, the manufacture is conducted and the product obtained with practical freedom from by-products. The carbon of the coke or charcoal is caused to unite with the oxygen and hydrogen of the decomposed water, the cycle of reactions of the present invention supplying the principal ancillary substances necessary to accomplish this in such manner that practically no by-products are left.

The Hord Color Products Co., Sandusky, Ohio, are building a large dye factory. Dr. D. Julian Block of Chicago has been active in developing processes.

Bituminous Coal Output—The estimates made by the Geological Survey for the first six months of 1916 are interesting as they reflect the great industrial activity which is going on in this country at the present time. According to the estimates, the output was 261,000,000, tons or the largest output ever recorded for a half year period. This is an increase of 35 per cent over the first six months of 1915 and of 5 per cent over the last six months of 1915. The exports to Canada have increased considerably.

The Nordberg Mfg. Co., Milwaukee, Wis., has issued Bulletin No. 28, describing poppet valve engines of three types, viz., full poppet, poppet-uniflow and poppet-Corliss. For ordinary non-condensing service, the high-speed, full-poppet valve engine shows the highest efficiency. For condensing service two types of engines are offered—Nordberg poppet-uniflow and Nordberg poppet-Corliss, the former being an engine with uniflow cylinder design, that is, exhaust ports in the cylinder barrel and poppet steam valves, and the latter a compound engine with a full poppet high-pressure cylinder and a Corliss valve low-pressure cylinder. The poppet-uniflow engine is particularly adapted to widely fluctuating loads on account of its flat steam consumption characteristic. Recently two of the largest uniflow engines so far constructed in this country have been shipped to the Youngstown Sheet & Tube Co., for steel mill drive. The poppet-Corliss engine is adapted to constant load or constant m.e.p. work, under which conditions it shows very high steam economy. A compound engine of this type, fitted to an ammonia compressor, showed by test a steam consumption of less than 10 lb. per indicated horsepower-hour.

The Flotation of Oxidized Ores*

BY O. C. RALSTON AND GLEN L. ALLEN

Concentration of natural sulphide ores by the flotation process has met with such success that attempts have recently been made to apply the process to the flotation of ores other than natural sulphides.

As inquiries on this subject are frequently received by the Bureau of Mines, it has been thought best to publish a summary of the results so far obtained from the experimental work on oxidized ores at the Salt Lake City station of the bureau, in co-operation with the department of metallurgical research of the University of Utah. The work has been directed by O. C. Ralston, assistant metallurgist of the bureau, and was carried on for the most part by G. L. Allen. N. C. Christensen and R. W. Johnson also assisted with the work.

As above stated, this paper is only a summary, or a preliminary report of the experiments on the flotation of oxidized ores. More complete details as regards the flotation of carbonate ores of lead will be given by the writers in a paper on that subject, and in the near future the bureau expects to publish a still more complete discussion on the flotation of oxidized ores of lead, copper and zinc.

Most of the experimental work in the laboratory at the Utah station has been with the oxidized ores of lead. Only minor attention has been given to the oxidized ores of zinc and of copper for the following reasons: Little success has been had with the zinc ores; many others are engaged in testing copper ores, so that there was no pressing necessity of experimentation with copper ores by the bureau, although an attempt is being made to co-ordinate the work of those who are willing to co-operate to that extent.

Sulphidizing and Flotation of Oxidized Ores

Flotation of oxidized minerals depends upon a preliminary "sulphidizing" by any method that will convert at least the surface of the mineral particles to a sulphide of the metal. This step is followed by flotation of the "artificial" sulphide, which results in a concentration of the metallic values in the low-grade oxidized ore being treated.

The methods of sulphidizing that have been investigated are as follows:

Sulphidizing (1) by the use of hydrogen sulphide on either the dry or the wet crushed ore; (2) by the use of solutions of the various sulphides and sulpho-compounds of sodium; (3) by the use of solutions of the various sulphides and sulpho-compounds of calcium; (4) by the use of sulphur vapor; (5) by the use of a sulphureted oil; (6) with colloidal sulphur.

It has been found that treatment by some of these methods will form a film of sulphide over the surface of the particles of such minerals as lead carbonate or copper carbonate, whereas in other cases the mineral particles are sulphidized to the core. Other methods failed to give any results.

CARBONATE OF LEAD ORES

All of the above methods of sulphidizing have been tested on a great number of carbonate-of-lead ores. Some of these ores contained silver and some contained lead as the principal metal. A number of the ores have been successfully concentrated and others refuse to yield to concentration by flotation. In general, a high alumina content (acid soluble) in an ore seems to prevent the application of sulphidizing and flotation. The purpose of this report is to give the main features of the flotation of oxidized ores of lead, as well as other ores.

In sulphidizing with hydrogen sulphide gas, as applied to the lead carbonate ores, it was found that the best method of applying the gas to a dry powdered ore was in a tumbling barrel with the gas inlet in the end. Sulphidizing in a glass bottle showed that the ore blackened quickly after the application of the hydrogen sulphide gas. On attempting to float out lead sulphide from the ore as soon as it had blackened it was found that a low extraction of lead was obtained and likewise a low-grade concentrate, unless the pulp was previously acidified with sulphuric acid. By acidifying the pulp, cleaner concentrates were floated but the extractions of lead remained low. Only by prolonged treatment with hydrogen sulphide gas could the extraction of the lead be raised to commercial grade. With a number of ores eight hours' treatment gave an extraction of over 80 per cent of the lead.

The use of hydrogen sulphide was considered for the reason that it can be generated quite cheaply. With iron matte available at \$5 to \$10 per ton, and sulphuric acid from \$5 to \$10 per ton, the cost of the hydrogen sulphide resulting, including labor, etc., is between \$30 and \$50 per ton. If this gas in combining with the metal in the ore produces only a superficial film of sulphide, and does not penetrate to the center of the particles, it might be possible to make a ton of the gas sulphidize many tons of ore.

Unfortunately hydrogen sulphide attacks the metallic particles of the ore with such avidity that by the time the latter are sulphidized sufficiently to permit of good extraction by flotation, they have also been sulphidized to the core, and practically a chemical equivalent of hydrogen sulphide, to the lead in the ore, has been absorbed. Even coarse pieces of ore in a bottle absorb the gas with evolution of heat, and on breaking open the pieces the black coloration is seen to have traveled deeply into the particles.

Owing to the fact that the value of the lead concentrate obtained is very low as compared to the amount of hydrogen sulphide necessary to sulphidize it, this process is not regarded as commercially practicable.

Application of hydrogen sulphide to the ground ore suspended in water does not seem to be subject to the same difficulty. True "filming" of the particles with a film of lead sulphide seems to take place, and the extractions possible after a short treatment with the gas are satisfactory. The speed of travel of molecules of hydrogen sulphide gas, as compared with the speed of travel of the same molecules in solution affords an explanation of the difference in the action of the gas when applied to dry pulverized ore as compared to its action when applied to pulp suspended with water.

The best results on lead carbonate ores have been obtained when sulphides of sodium were used for the sulphidizing agent. The sodium sulphide must necessarily be introduced in solution and seems to cause true filming. The sulphides of sodium considered commercially applicable are the normal sulphide of sodium, Na_2S ; sodium polysulphides, Na_2S_x and Na_2S_y , and the sulphhydrate of sodium, NaSH . Of these the latter, the sulphhydrate, seems to be very effective, as is evidenced by the quicker blackening of the pulp, and the deeper, blacker color formed. The normal sulphide is almost as effective; the polysulphides seem to be the least active. Different ores require 10 minutes to 24 hours of contact with the solutions of sodium sulphide used, depending on the properties of the ore and on the strength of the solution of sodium sulphide. Amounts of sodium sulphide varying from 10 to 20 pounds per ton of ore are usually sufficient, and should be applied to pulp containing about one ton of water per ton of ore, in order that the solution may be as strong as possible during

*A report issued by the Bureau of Mines (Van H. Manning, Director).

the sulphidizing stage of the process. After a good black color has developed, and the color has ceased to increase in blackness, the pulp is diluted with water to a 3:1 or 4:1 mixture and floated in either mechanically agitated or pneumatic machines. The market for sodium sulphide is limited, and it should be obtainable at considerably less than 2 cents per pound.

The polysulphide of calcium, obtained by boiling powdered sulphur with slacked lime, seems to be satisfactory for ores that yield easily to sulphidizing, but is sluggish in its action, as compared to the sulphides of sodium. The normal sulphide of calcium is only slightly soluble, and hence its use was discontinued as a possible sulphidizing agent. The sulphydrate of calcium is the most active of these reagents, but has not been tested to any extent in this work, as there is doubt as to whether it would be commercially feasible to prepare such a compound.

Sulphidizing with sulphur vapor has been tried with little success, for the reason that it must be applied at a temperature above the boiling point of sulphur in order to prevent condensation of the sulphur. This means that the ore must be heated to a temperature above 445° C. There seems to be no difficulty in obtaining elemental sulphur vapor commercially, as pyrite will give up half of its sulphur content when heated in a closed space, and sulphur dioxide gas can be reduced to elemental sulphur by passing it through a heated zone in the presence of a reducing agent. As lead itself is easily reduced from its carbonate form, the temperature might as well be raised to the point where the lead can be liquated out, a reducing atmosphere being used instead of a sulphidizing atmosphere.

The use of a sulphureted flotation oil, in which loosely combined sulphur is available for combination with carbonates of lead or other metals, and the rest of the oil is then available for "oiling" the artificial sulphide, has given very little encouragement in the tests conducted by the bureau.

Finally colloidal sulphur, mentioned as a possible method of sulphidizing, does not seem to combine with lead carbonate at all. It floats as a white lining of the air bubbles in the flotation machine, and brings up very little lead with it.

Usually the precious metals contained in a lead carbonate ore accompany the lead. The writers have noticed that the silver extraction will lag behind the lead extraction when the ore is sulphidized with sodium sulphide, and that the reverse has usually been true when hydrogen sulphide was used.

The importance of sulphidizing flotation is due to the fact that there are many deposits of lead carbonate ore in all of the Western States, and many of these ores have been milled with varying success. Frequently the lead carbonate can be satisfactorily concentrated by gravity methods, but often it is found that the particles of lead carbonate go into the slimes and are lost. Tailing heaps containing 5 to 10 per cent of lead are common. The object of this investigation is to determine whether sulphidizing flotation could not be applied to the treatment of the deposits of lead carbonate above mentioned, to prevent the waste that now takes place when these ores are treated by gravity concentration processes, and render amenable to treatment carbonate ores that are too low grade to be treated by present methods.

The General Engineering Co., of Salt Lake City, Utah, has carried on extensive tests of different lead carbonate ores with varying success, according to the ore tested. The company owns several sulphidizing patents, which it has either patented or purchased.

A flotation plant to apply sulphidizing and flotation

to an ore containing lead, silver and gold is being constructed by the Prince Consolidated Mining Co. at Pioche, Nev., for the treatment of two tailing dumps from former pan-amalgamation and cyanide operations in that vicinity. This plant was expected to be in operation by July 1, 1916.

OXIDIZED COPPER ORES

Many attempts have been made, both by large operating companies and by other experimenters, to float the carbonate and other oxidized minerals of copper. For that reason the testing of such ores by the writers has been limited.

Hydrogen sulphide seems to be by far the best medium for sulphidizing oxidized copper ores previous to flotation. When applied to the dry ore, the writers found the same conditions as those mentioned for lead; the particles are sulphidized to the center, which requires an excessive amount of hydrogen sulphide. Applied to the wet pulp, the hydrogen sulphide seems to cause true filming. The writers' work has yielded black concentrates, but they are informed by Mr. Callow of the General Engineering Co. that the company has been able to reduce the amount of sulphur used to a point where the froth is green with slightly coated malachite. He states that as little as one-half pound of sulphur per ton of ore is giving good extractions in the plant of the Magma Copper Co., at Magma, Ariz., where his company has put in the first successful installation of this kind.

Sodium sulphide has been tested by a number of the larger companies who have some oxidized copper minerals in their sulphide ores. The amount of oxidized copper in such ores is usually a fraction of 1 per cent, so that two or three pounds of sodium sulphide per ton of ore are all that is necessary. This is usually added to the machines during flotation, or to the mixing tanks before flotation. The writers' experience is that if some little time of preliminary contact is allowed before flotation is attempted, better sulphidizing of the material will result.

Calcium polysulphide has been used for some time in a number of the large copper concentrating mills with indifferent success, and seems to be detrimental in some instances. On the ores tested by the writers fair results were obtained if the calcium polysulphide was allowed to act until the ore had become well blackened.

It is stated that sulphur vapor was tested at one of the large plants for flotation of oxidized forms of copper and gave better results than any other method of sulphidizing. Of course this method has the disadvantage of having to be applied to dried, heated and finely divided ore.

Sulphureted oils are being used at a number of plants to supplement other methods of sulphidizing and considerable secrecy is observed as to the technical details of this work.

So far as the writers know, colloidal sulphur does not assist in the flotation of oxidized forms of copper. Neither has the silicate of copper been successfully floated by sulphidizing flotation. It will blacken when sulphidized, but resists flotation. Possibly it still presents a silicate surface, rather than a sulphide surface to the flotation elements. For this reason a number of the large copper companies are seriously contemplating leaching the oxidized copper ores, rather than lose what silicate of copper may be present.

Repeated attempts to float the natural sulphides along with sulphidized minerals have failed, as the sulphidizing agents cause trouble with the flotation of the natural sulphides. By careful adjustment this difficulty has

been solved in one plant, though the details are not available.

OXIDIZED ZINC MINERALS

Attempts to float the oxidized particles of zinc from their ores, both before and after sulphidizing by most of the above methods, have met with no success whatever in the laboratory experiments of the writers. They are informed that some headway was made with the problem by Professor Traphagen, at the Colorado School of Mines, but that the sulphide film seemed to come off too easily. However, poor results were obtained, whatever the cause.

The writer's experience has been that most of the carbonate ores of zinc contain important amounts of the silicate, and this may be one reason for the non-success of this work, for the same reasons that copper silicate will not float.

Direct flotation of oxidized minerals of the kind mentioned, so far as known, has not been successfully accomplished. In all of the successful work witnessed by the writers there has been some form of alteration of the oxide to the sulphide. A number of parties claim to be successful in the flotation of copper carbonates without sulphidizing, and others in the flotation of scheelite, fluorite and magnetite. The authors were unable to verify these statements.

Results of Tests

Some of the best results and some average results which have been obtained in the work at the Utah station are given in the table following.

RESULTS OF SULPHIDIZING AND FLOTATION OF OXIDIZED ORES
LEAD-SILVER ORE

Ore No.	Source of Ore	METAL CONTENT OF ORE		METAL CONTENT OF CONCENTRATE		EXTRACTION	
		Lead, per Cent	Silver, Ounces	Lead, per Cent	Silver, Ounces	Lead, per Cent	Silver, per Cent
1	Daly Judge mine, Utah	16.1	20.6	33.6	41.5	83	80
2	May Day mine, Utah	4.2	2.36	24.6	9.6	80	55
3	May Day mine, Utah	4.5	2.8	28.4	12.04	86	64
4	May Day mine, Utah	4.5	2.8	26.1	11.5	73	48

LEAD ORE

Ore No.	Source of Ore	Lead, per Cent	Lead, per Cent	Lead, per Cent
5	Wilbert Mill dump, Idaho	5.77	28.2	54
6	Seranton Mine, Utah	8.74	65.0	88

LEAD-SILVER-GOLD ORE

Ore No.	Source of Ore	Lead, per Cent	Silver, Ounces	Gold, Ounces	Lead, per Cent	Silver, Ounces	Gold, Ounces	Lead, per Cent	Silver, per Cent	Gold, per Cent
7	Shattuck mine, Ariz.	15.42	12.88	0.05	48.3	45.2	0.128	88		70

COPPER-SILVER-GOLD ORE

Ore No.	Source of Ore	Copper, per Cent	Silver, Ounces	Gold, Ounces	Copper, per Cent	Silver, Ounces	Gold, Ounces	Copper, per Cent	Silver, per Cent	Gold, per Cent
8	Grand Central mine, Utah	0.60	4.80	0.22	4.75	32.9	1.28	67	75	75

ZINC ORE

Ore No.	Source of Ore	Zinc, per Cent	Zinc, per Cent	Zinc, per Cent
9	Honorine mine, Utah	28.45	27.2	Nil

METHOD OF SULPHIDIZING

Ore 1.—Two hours' treatment with H_2S gas on dry ore.

Ore 2.—Four hours' treatment with H_2S gas on dry ore.

Ore 3.—Eighteen hours' treatment with 1 per cent solution of Na_2S , 20 lb. per ton of ore.

Ore 4.—Three hours' treatment with 0.8 per cent solution of CaS , 16 lb. per ton of ore.

Ore 5.—Four hours' treatment with 1 per cent solution of Na_2S , 20 lb. per ton of ore.

Ore 6.—One-half hours' treatment with 6 per cent solution of Na_2S , 12 lb. per ton of ore.

Ore 7.—One-half hours' treatment with 0.75 per cent solution of Na_2S , 15 lb. per ton of ore.

Ore 8.—Short-time treatment with hot 1 per cent solution of Na_2S , 20 lb. per ton of ore.

Ore 9.— Na_2S or H_2S in various amounts.

PATENTS ON SULPHIDIZING AND FLOTATION PROCESSES

A list of patents dealing with methods of sulphidizing and flotation follows:

U. S. Patent	807,501	Dec. 19, 1905	A. Schwarz.
U. S. Patent	1,094,760	April 28, 1914	J. T. Terry.
U. S. Patent	1,098,668	June 2, 1914	H. B. Hovland and G. B. Frankforter.
U. S. Patent	1,140,865	May 25, 1915	R. F. Bacon.
U. S. Patent	1,140,866	May 25, 1915	R. F. Bacon.
U. S. Patent	1,159,942	Nov. 9, 1915	H. B. Hovland.
U. S. Patent	1,180,816	April 25, 1916	R. F. Bacon.
British Patent	26,019	Nov. 10, 1909	H. L. Sulman and H. K. F. Picard.

(Note.—Provisional specifications 28,612, Sulman and Picard, applied for Dec. 7, 1909, and 29,616, applied for Dec. 17, 1909, are incorporated in British Patent 26,019.)

Synopsis of Recent Chemical and Metallurgical Literature

Gold and Silver

Gold Dredge.—What is reported to be the largest ladder dredging unit thus far constructed is described in *Engineering Record*, June 24. The hull was launched at Hammonton, Cal., in April. It is equipped with an endless chain of 100 buckets, each of 16 cu. ft. capacity. Material is to be excavated from a depth of 82 ft. below water level. The monthly capacity is 300,000 cu. yd. of material, and this yardage is handled with a crew of but three men. The dredge is operated by a 400-hp. motor for driving the excavator, and six other motors ranging from 35 to 150 hp. The hull is built of structural steel and weighs about 1000 tons without mechanical equipment. This dredge is to be operated on the Yuba River by the Yuba Consolidated Gold Fields Company, and is to be duplicated by a sister dredge to be launched this fall.

Copper

Dust Losses at Copper Queen Reduction Works.—In an elaborate paper prepared by Mr. J. MOORE SAMUEL of Douglas, Ariz., for the September meeting of the American Institute of Mining Engineers, the author gives the results of measuring dust losses from blast furnaces, converters and roasters at the Copper Queen smelter. The following essentials of a suitable method for determining such losses are laid down:

1. The sample of gas taken for filtration must be representative of the whole volume of gas, that is to say, it must have the same dust content. This condition will be fulfilled in all cases if the gas sample is drawn off without change of rate of flow. Then it will contain the same proportion of entrained or suspended particles of dust as the original gas. In the case of flue gases which contain only fume, at a temperature above or near the sublimation point, this condition need not be adhered to since the fume will not behave as entrained particles, but more nearly as a true gas. Consequently the gas sample in this case only may be drawn off at any rate of flow.

2. The gas sample taken must be large enough (a) to yield sufficient dust to permit of accurate chemical and physical examination; (b) so that the ratio of the total volume of gas passing through the flue to the volume of gas sample taken, shall not be too large.

3. The methods of measurement of gas volumes should be such that an occasional independent check can be made.

After describing in some detail the methods employed, which can be best obtained from the original paper and the tabulated results and drawings, the author gives some condensed data on the improvements secured through changes in practice suggested by the tests.

In 1909 when the tests were started, the equipment consisted of five 42 x 240-in. and five 42 x 216-in. blast furnaces and eight acid-lined converters of barrel type, 8 x 11 ft. Following these original tests an experimental settling chamber of 23 sq. ft. cross-sectional area and 50 ft. long was erected to make tests of dust settling at different rates of gas flow. Later this test chamber was lengthened to 100 ft. As a result of the experiments it was concluded that flues or settling chambers need not be longer than 125 ft. if the gas velocity did not exceed 150 ft. per minute, and that this velocity could be exceeded if wires or screens were placed in across the direction of flow. The dust chamber was subsequently enlarged to conform to these conclusions, and further tests were made. Comparing the results obtained with previous tests made under the same operating conditions, there is a decrease in dust loss of 103,800 lb. per day (from 164,680 to 60,860), and in the copper loss of 10,800 lb. per day (16,142 to 5355). That is a decrease of 63 per cent of dust loss and of 67 per cent of the copper loss.

In 1913, after the reverberatory and roaster plant had been blown in, the fine ore was no longer charged into the blast furnaces. Another series of tests was made under these conditions which shows a further decrease, the dust loss being 40,000 as against 60,000, and the copper loss 2589 as against 5355. It should be noted, however, that one less blast furnace was in operation.

Reverberatory dust losses are probably nominal and have not been determined.

The roaster losses have been determined under the following different conditions of operation:

	Roasters in Operation	Draft	Feed
(1)	8	Low	Fine
(2)	15	Medium	Mixed
(3)	15	High	Mixed
(4)	15	Low	Mixed
(5)	14	Low	Coarse

The roaster plant consists of sixteen six-hearth McDougall roasters, 18 ft. in diameter. The flue is 144 ft. long with a free cross-sectional area of 1235 sq. ft. Wires are hung in all but the first and last 12 ft. of the flue, or in a total length of 120 ft. From the tabulated results of roaster dust losses we note the following:

Roaster Feed	Tons of Charge Roasted in 24 Hrs.	Dust Loss			Metal Loss in 24 Hrs.			Draft at End of In-flue to Roaster Dust-Chamber, Inches of Water
		Lb. in 24 Hr.	Per Cent of Roaster Charge	Grains of Dust per Cu. Ft. of Gas	Gold, Oz.	Silver, Oz.	Copper, Lb.	
Concentrates	361	10,160	1.414	0.259	.....	17.6	605	0.15 to 0.20
Concentrates	752	52,704	3.508	0.894	0.75	101.7	4,589	0.34 to 0.38
and sulphide	795	71,940	4.623	1.077	1.04	147.5	6,941	0.46 to 0.50
ore	806	62,000	3.831	1.072	0.66	111.9	5,308	0.26 to 0.30
ulphide ore	576	25,950	2.243	0.478	0.50	20.5	1,726	0.26 to 0.30

The roaster dust loss seems to depend on the tonnage treated by the roasters, the roaster draft, and the size of the particles fed. It is found in practice that the roaster draft has a great effect on the capacity of the furnaces, but our tests also show that increase of draft, or increase of tonnage treated, result in prohibitive dust losses, so that now the roaster draft is kept at

the absolute minimum which is required to carry away the gases.

Pumping

Pumping Costs with Diesel Engines.—Some interesting data on pumping water with Diesel engines is given by H. W. GOCHNAUER of Appleton, Wis., in the June 3rd issue of *Engineering Record*. For the year ended April 1, 1916, these engines pumped at an oil cost of \$2.82 per million gallons, against a head of 185 ft. The installation consists of two 225-brake-hp. three-cylinder, four-stroke Diesel oil engines. Each engine is direct-connected to two Deane double-acting triplex pumps of 2,000,000-gal. capacity each. In addition to pumping water the engines operated two 15-kw. 110-volt D.C. generators for lighting, without sensibly increasing the fuel-oil consumption. The operating labor consists of a chief engineer and three assistants, who work in two two-man shifts. For the year indicated the engines were operated 5948 hr., consuming 44,610 gal. of oil and pumping 569.43 million gallons of water. The fuel-oil average consumption per million gallons of water pumped was 78.6. Fuel oil cost 3.6c. per gallon, or \$2.82 per million gallons; lubricating oil, 36c.; labor, \$6.48; materials, \$1.98; total, \$11.64 per million gallons.

The efficiency of an air-lift is reported in the same issue of the *Engineering Record*. Total depth of well, 120 ft.; diameter, 8 in.; depth to foot-piece, 106 ft.; foot-piece to umbrella, 115.5 ft.; water eduction pipe, 5 in.; air pipe, 1 1/4 in. The lift developed an efficiency of 59.6 per cent measured between the steam end of the compressor and the point of delivery of the water. Air consumption was 50 cu. ft. free air per minute. The curve of efficiency shows a steady falling off as the pressure is increased and more water pumped. Thus with 100 cu. ft. free air per minute, pumping 392 gal. per minute, the efficiency was only 40.2 per cent. This decrease is expected for two reasons: First, because of the lower submergence when pumping the larger quantity; second, because of the greatly increased friction of water and consequently slippage of air at the higher velocities of discharge. This friction and slip is held to be the greatest contributing cause of inefficiency in air-lifts.

Power and Transportation

Diesel Engines vs. Steam Turbines for Mine Power Plants.—In a paper to be presented at the Arizona meeting of the American Institute of Mining Engineers, Mr. HERBERT HAAS of San Francisco discusses the subject of cheap power for mining and metallurgical plants, and gives some comparative data on Diesel engines and steam turbines. The supply of cold water for condensing purposes is a factor of importance, since about twelve times as much water will be required for condensing purposes with steam turbines under general conditions as is needed for jacket-cooling of two-stroke cycle Diesel engine; four-stroke cycle Diesel engines require only one-twentieth of the cooling water. Another condition favoring the use of Diesel engines is the high load factor at which most mine power plants operate.

The author tabulates the cost of producing power with (a) four 3000 B.h.p. (2000 kw.) Sulzer Diesel engines direct-connected to alternators and exciters, and (b) with two 6000-kw. steam turbines. For a plant of each type costing \$720,000 and fixing usual costs for labor, maintenance (1 per cent cost of installation per year), interest and amortization, and fuel oil at \$1.25 per barrel of 320 lb., the following comparative cost data are deduced:

	8000 Kw.		6000 Kw.		4000 Kw.		2000 Kw.	
	Per Kw.-yr. Doll.	Per Kw.-hr. Cts.	Per Kw.-yr. Doll.	Per Kw.-hr. Cts.	Per Kw.-yr. Doll.	Per Kw.-hr. Cts.	Per Kw.-yr. Doll.	Per Kw.-hr. Cts.
Diesel engine.	39.81	0.4545	44.51	0.5081	53.89	0.6152	83.96	0.9356
Steam turbine.	61.75	0.7051	63.50	0.7259	76.60	0.8746	111.70	1.2778

In general, the selection of either type of prime mover will be governed by the following economic considerations:

1. Fuel is of chief influence on the total power cost where both the B.t.u. price and load factor are high. These conditions favor the use of the Diesel engine.

2. Interest and redemption (amortization) are of chief influence on the total power cost with low B.t.u. price and low load factor; this applies particularly to stand-by plants, which are operated only occasionally or have to supply recurring peak loads. The installation cost of such plants must be kept as low as possible so as to avoid heavy capital charges distributable over a relatively small kilowatt-hours output of the station. Such conditions favor the steam turbine.

3. Exceptions to (2) are cases where the constant and instant readiness of the Diesel engine give it preference, and installation cost is of secondary importance. Here we would have to balance the cost of keeping boilers under steam continuously against the difference of interest charges of steam-turbine and Diesel engine plants.

4. Power plants located at the source of the fuel, either in the oil fields, or at the coal mine, and therefore enjoying the advantages of a very cheap fuel supply, will select prime movers costing least to install, i.e., steam turbines, since fuel expenditures will weigh less than interest and redemption charges.

5. In many cases combination plants using Diesel engines for supplying the continuous and nearly constant main load, and steam turbines for furnishing periodically occurring peaks by the use of high-duty boilers with large water and steam spaces, capable of being forced when necessary, will prove most profitable. Thus, as an example, the periodical peaks produced in hoisting may be taken care of by a turbine floating on the line and operating in parallel with Diesel engines that supply the main load and operate constantly at or near full load.

6. Steam power will remain the cheapest power wherever waste-heat gases are available, as for instance gases from reverberatory smelting furnaces, where nearly one-half of the fuel used in smelting can be utilized for steam generation. Nearly 3,000,000 B.t.u. for every ton of charge smelted are thus available for steam generation, or about 150 hp.-hr. per ton of charge which is smelted.

7. Up to capacities of 1000-hp. steam turbines can compete with Diesel engines only in special cases, such as supplying exhaust steam for heating purposes. For such small units, particularly for greatly varying loads, high-grade reciprocating steam engines are preferable. For larger plants, from 1000 to 10,000 kw. capacity, careful analysis must be made of the relative advantages of Diesel engines and turbines, a knowledge of the load factor, fuel prices and water conditions being necessary. Power plants larger than 10,000 kw. using units from 6000 kw. upward, preferably use steam turbines, unless a combination of high load factor, high fuel cost, and poor water conditions favor a Diesel plant. This is a special condition frequently met with in actual practice.

Recent Chemical and Metallurgical Patents Iron and Steel

Opening Frozen Tap-Holes.—A method of opening frozen tap-holes of blast or open-hearth furnaces, patented by HENRY C. WITZ, of Johnstown, Pa., consists in applying a heated iron bar to the hard or frozen metal in the tap and continuously feeding oxygen to the heated bar so as to maintain the latter in an incandescent condition and thus enable it to eat its way through the frozen crust. (1,186,358, June 6, 1916.)

Treatment of Ores to Produce Alloys.—The direct production of an alloy of iron and nickel, or iron and any other metal such as manganese which may be contained in iron ores, is patented by FREDERICK A. EUSTIS, of Milton, Mass., and CHARLES P. PERIN of New York City, and assigned to the Moa Bay Iron Co. The object is to avoid the separate extraction of one of the contained metals when it is possible to obtain a desirable alloy by direct reduction. Considering the case of Cuban iron ore containing about 1 per cent of nickel, a parcel of ore is divided into two parts, one of which is to be treated for the extraction of a predetermined amount of its nickel which is subsequently added to the second part, thereby enriching the mixture in nickel, whereupon the mixture is smelted to produce an iron-nickel alloy. The treatment of the first part of the ore for extraction of nickel may be accomplished by roasting with sulphur-bearing material, yielding a sulphated product from which nickel sulphate can be leached. The nickel solution thus obtained may be precipitated, and the precipitate added to the second part of the ore prior to smelting. Various modifications of the method are given. (1,185,187, May 30, 1916.)

Copper, Lead and Zinc

Process of Refining Copper.—A substitute for the ordinary method of refining copper by oxidizing and then reducing with poles is patented by EDWARD C. KING, of Cananea, Mex. His method consists essentially in introducing hydrocarbon oil under suitable pressure into a bath of molten copper. He claims that the oil not only acts to eliminate gaseous or metallic impurities, forming a slag of the latter, but after all the impurities except oxygen have been removed, continuation of the operation will ultimately expel oxygen and give a refined copper. (1,183,736, May 16, 1916.)

Hydrometallurgy of Lead and Zinc Ores.—A method of treating lead and zinc sulphide ores by roasting and leaching with a chloride solution is patented by ROYAL S. HANDY, of the Bunker Hill & Sullivan Company, Kellogg, Idaho. The roast is conducted so as to yield as much lead sulphate as possible, after which the material is agitated with hot sodium chloride solution. Lead goes into solution as chloride, and when the solution cools much of the lead salt crystallizes out, while the solution can be used again or diverted to a regenerating system. Any unconverted sulphides remaining in the roasted material may be recovered by leaching with ferric chloride, whereby chlorides of the metals are obtained and precipitated on suitable metals: lead on iron, silver on lead, etc. The zinc solution may be electrolyzed. (1,185,902, June 6, 1916.)

Dry Chloridizing of Sulphide Ores.—In a patent issued to JOHN L. MALM, of Denver, Colo., the inventor discloses his method of treating sulphide ores of lead, zinc and iron, with dry chlorine gas, rendering the iron insoluble and the other metals soluble. The essential apparatus includes a tube-mill, a roasting furnace and an agitating machine. The dry ore is introduced into the tube-mill where it is subjected to the action of dry chlorine gas. Reaction proceeds to a point of par-

tial chloridization of the valuable metals and the formation of either ferrous or ferric chloride. The partly chloridized mass is then passed to the roasting furnace where chloridization is completed by the decomposition of the iron chloride, forming inert iron and manganese compounds and yielding chlorine to complete the chloridizing of the other metals. The latter are thus rendered soluble, and separation from iron and manganese offers no difficulty. Any gold and silver in the ore may be recovered by cyanidation or amalgamation after the pulp is agitated with the leaching solution and filtered. The leaching solution is hot water, which takes up the chlorides of lead, copper and zinc, leaving the inert iron and manganese compounds behind. (1,185,817, June 6, 1916.)

Electrolytic Apparatus.—An electrolytic cell in which the anodes are placed vertically above the cathodes is shown in Fig. 1, being the patented invention of WILLIAM E. GREENAWALT, of Denver, Colo. Another feature of the cell is the anode bell which collects the anode gases, either chlorine or oxygen, depending on whether copper chloride or sulphate is electrolyzed. The oxygen thus formed may be removed for the treatment

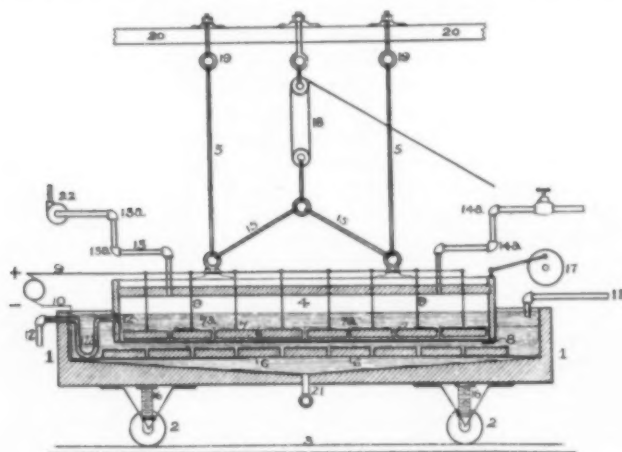


FIG. 1—ELECTROLYTIC CELL

of ore by cyanidation, in which process oxidation plays an important part. Since the oxygen obtained from electrolysis at high current densities contains much ozone, the gas has an enhanced oxidizing power. Referring to the figure, 1 represents a shallow tank mounted on wheels; 4 is an inverted tank or anode bell suspended by suitable means as shown and dipping below the electrolyte in the cell. The cathodes are represented at 6 and the anodes at 7. Connections for anodes and cathodes are shown at 9 and 10, and inlet and outlet for solution at 11 and 12. Since the anodes are placed vertically over the cathodes, the anode gases will rise through the electrolyte into the anode bell and will not come in contact with the deposited metal at the cathode. The rising of the anode gases and the prevention of short-circuiting is facilitated by the oscillation of the anode bell, which has a small amplitude of vibration. (1,183,188, May 16, 1916.)

Hydrometallurgy of Zinc Ores.—A method of preparing pure zinc sulphate solution from zinc ores, particularly from roasted silicate zinc ores, is patented by SHUNJIRO ARAKI, of Osaka, Japan. The pulverized roasted ore is treated with the chemical equivalent of a 20 per cent sodium bisulphate solution, dissolving the zinc, together with lead, copper and small quantities of iron and manganese. The solution is filtered and treated with zinc in the form of dust or sheets to remove the copper and lead. The solution is next neutralized with caustic alkali, and an oxidizing agent like

bleaching powder is added to effect oxidation of iron and manganese. These metals separate in gelatinous form, but small amounts remain in colloidal form, difficult of separation. These are then removed by boiling with hydrated silicic acid, formed by neutralizing sodium silicate with a mineral acid. When the neutralization is effected and the solution heated, insoluble silica is precipitated and carries down with it the remaining traces of iron and manganese. From the pure zinc sulphate solution thus prepared, zinc oxide or metal can be formed by appropriate means. (1,185,757, June 6, 1916.)

Treatment of Flue-Dust.—In Fig. 2 is given a diagram of a method of treating flue-dust from roasting or blast furnaces, according to the specifications of a patent granted to FRANCIS C. RYAN, of Hammond, Ind. The material is first leached with hot water to extract

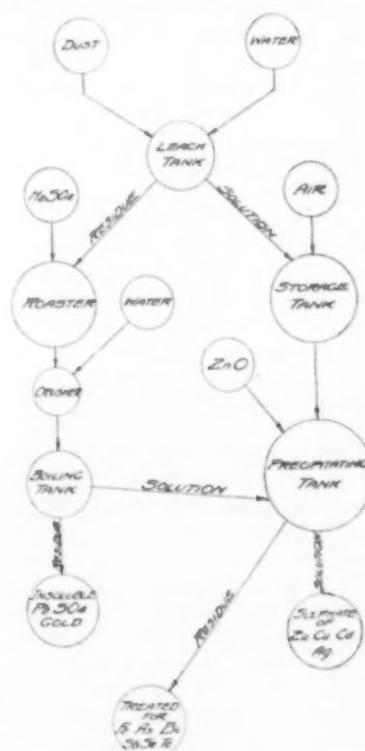


FIG. 2—TREATMENT OF FLUE DUST

all water-soluble compounds, such as the sulphates of zinc, arsenic and iron. The leach liquor is blown with air to oxidize the iron in particular. The residue is sulphated by roasting with sulphuric acid, the excess of which aids in the solution of basic anhydrous salts of iron, copper, zinc, etc. The roasted material is boiled with a limited amount of water, and the sulphate solution of silver, copper, zinc and iron is separated by filtration. To it is added the water solution first obtained, and the whole is precipitated with zinc oxide, throwing down iron, bismuth, arsenic antimony, selenium and tellurium, while the sulphates of silver, copper, zinc and cadmium remain in solution. Precipitate and solution are separated, and treated for the recovery of their metallic contents by acceptable metallurgical methods. 1,182,320, May 9, 1916.)

Roasting of Zinc Ores.—In the roasting of zinc blende for retort smelting, there remain in the roasted product certain constituents which have a prejudicial effect on the retort process by causing corrosion of the retort walls, evolving gases which carry zinc fumes out of the condenser, and yielding sulphur gas which forms zinc sulphide again. In order to overcome these objections to the ordinary method of roasting, CHARLES A. H. DESAULLES, of New York City, proposes to add carbon, in the form of anthracite coal, to the roasting ore, with the effect that the undesirable compounds are broken up at the higher temperature produced. Zinc sulphate is decomposed, leaving the oxide; lead, barium and calcium sulphates are reduced to sulphides; magnesium sulphate is changed to oxide; ferric oxide is changed, in part to metallic iron, Fe_2O_3 and FeO , which are not so destructive in retorts as Fe_2O_3 . The net result is to relieve the retort of a considerable proportion of the burden usually placed upon it. (1,183,172, May 16, 1916.)

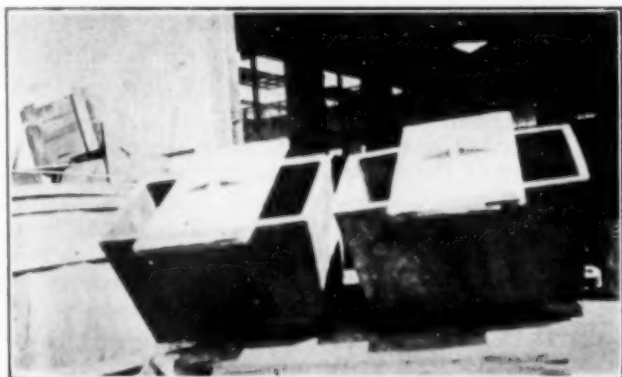
New Development in Castings of a Heat-Resisting and Non-Corroding Alloy

It is well known that there are very few metals or alloys which are suitable for working at temperatures between 1750 to 1800 deg. Fahr., without losing their strength rapidly, being volatilized or melting completely, and at the present time there is nothing in this line generally commercially available for industrial purposes.

The Driver-Harris Wire Co., Harrison, N. J., manufacturers of the nickel-chromium alloy "nichrome," which is well known in the electrical trades throughout the world as a resistor, has been, for some time past, developing this product in the form of castings and this research has been quite successful and remarkably interesting results have been achieved; the most important of which is, no doubt, the demonstration and practical service with extreme long life of "nichrome" in the cast form, compared with iron for work at high temperatures.

The company has been manufacturing these castings now for about a year and they are used in a great variety of different lines of industrial work. Patents have been assigned to the company by Mr. John C. Henderson, an engineer of the company, for the manufacture of these castings.

One of the new cast products of "nichrome," which has found much favor among manufacturers, especially in the automobile industry, is the carburizing box, used for heat-treating many different kinds of steel parts.



HEAT-TREATING BOXES OF NICHROME

Among the advantages which we note casually in this product, over the cast-iron box, are the following:

It possesses the characteristics of retaining its strength, as well as its shape, at high temperatures and does not become distorted, warp or bulge, as in the case of the iron boxes.

Marked economy is noted through saving in time, as the "nichrome" box may be quenched in water while red hot, thus saving the space and handling of reserved iron boxes.

Due to its far greater durability it may be made one-half the thickness of the iron box and thus save considerable labor in handling. These boxes may be had with walls cast 5/16 in. to 1/2 in.

Due to the fact that the box retains its strength and does not bulge the capacity of the furnace and tonnage of the product treated are increased appreciably. In the case of iron boxes it is a common thing to see the box cave in or warp badly. Another important advantage which should not be overlooked on this cast box, is the economy through long life, as the box loses very little of its tensile strength at working temperature of 1750 to 1800 deg. Fahr.

Among the cast products of the alloy, we find the much used pyrometer protection tube. This type of tube is now used very extensively and it is rapidly displacing the porcelain tube, which is fragile and very easily broken. In one case the tubes showed a life of 4000 hours.

It may be well to mention that a very interesting line of research is being conducted on metal crucibles of nichrome. Indications now are that these crucibles will very materially change the present practice in the melting of copper, brass and similar materials. Some very interesting results have been obtained from crucibles made to hold up to 175 lb. of metal and various metals have been melted to observe the effect which they had on the crucible. Brass, copper and phosphor copper have been melted, without the crucible showing any signs of deterioration. This is very important when we consider that phosphor copper has a corroding action on most all types of crucibles.

The writer saw one nichrome crucible in which phosphor-copper had been melted and which had been placed in white-hot coke and which had been used in oil vapors and other kinds of fire. About 50 heats had been made in this crucible and no signs of deterioration were visible. The nichrome crucible possesses the desirable property of not "alloying."

Tests made in No. 40 to No. 50 crucibles (the crucibles hold about 3 lb. to a number, thus No. 50 holds about 150 lb.), showed that metals could be melted quickly. Melts were made in about 40 minutes and required no especially careful handling or preliminary seasoning. The tests on the crucibles have not been entirely completed and it will be some time before the company will place them generally on the market.

Among other interesting products which have been made is a skimming ladle to be used in connection with a brass pot. When the brass pot is poured, the ladle is held in the neck of the pot, to keep back any dross or foreign substance floating on the top. Furnace bottoms, supporting frames, furnace floors to cover the fire bricks in heat-treating furnaces and in the chains and conveying parts of the continuous furnaces are other interesting uses. Furnace nozzles for oil burning have been tried out successfully, glass molds are being experimented with and a large pot for lead hardening and cyanide hardening has also been tested and has been found to offer many advantages. Some sections of pipe 15 in. in diameter and about 12 in. long have also been made.

It might be well to mention some of the other properties of nichrome as they should prove of general interest. In using nichrome wire baskets for pickling purposes and for heat-treating work, one of these baskets was used for six months in acid-dipping in which it was subjected to 40 deg. nitric acid, 40 deg. muriatic acid and 66 deg. oil of vitriol, also a mixture of several acids. No signs of the metal being affected were apparent. An ordinary brass basket lasted only four to six weeks at the same sort of work. In another case, a basket for heat-treating work was run through an annealing furnace at 1400 deg. Fahr. and dipped hot in 1:4 sulphuric acid. This process was carried on 140 times without any effect on the basket.

Nichrome can be readily machined, requiring no special tools. It has a tensile strength about twice that of ordinary cast iron and about the same hardness.

The development of these heat-resisting castings is very interesting and while some products are fully developed, the industry is just getting started and interesting developments in the future may be looked for.

The company expects to carry on considerable research work in the development of new castings.

Uranium in High-Speed Steel

The most recent development in high-speed steel is the remarkable effect of the alloy uranium on this class of material. This is shown by the results of tests of uranium high-speed steel in comparison with regular high-speed steel at present in use, given in Table I.

TABLE I

Tool	Feed, In.	Speed, F.p.m.	Cut, In.	Remarks
U-a.....	3/32	103	3/8	Ran 5 in.
A.....	3/32	103	3/8	Ran 2 1/2 in.
Material cut: loco. axle				
U-a.....	1/16	74	5/8	Ran 12 in.
A.....	1/16	74	5/8	Ran 2 in.
U-a.....	1/16	64	5/8	Ran 8 in.
A.....	1/16	64	5/8	Ran 2 in.
Material cut: loco. crankpin				
U-1.....	1/16	75	1/4	Went over once distance of 14 in. On second lap went 3 in.
B.....	1/16	75	1/4	Went distance of 4 in.
D.....	1/16	75	1/4	Went distance of 1 in.
Material cut: .50 per cent carbon 12 in. shaft				
U-1.....	1/16	51	5/8	Went over twice. Cut changed to 3/8 in. on second turn.
C.....	1/16	35	5/8	Did not go 1 in.
Material cut: 8 in. shaft 7 ft. 5 in. long				
U-1.....	1/32	75	5/8	Ran 18 in.
U-2.....	1/32	75	5/8	Ran 13 in. Speed increased to 90 f.p.m. and ran 11 in. Tool still good.
B.....	1/32	75	5/8	Ran 11 in.
Material cut: 6 in. shaft				
U-4.....	1/16	60 to 65	5/8	Went 8 in.
U-2.....	1/16	65	5/8	Went 4 in. Speed increased to 80 f.p.m. and went 3 1/2 in.
Material cut: 10 in. shaft				
U-1.....	3/64	55	5/16	Went 16 in.
U-5.....	3/64	55	5/16	Went 15 in.
B.....	3/64	55	5/16	Went 2 1/2 in.
Material cut: 12 in. shaft 22 ft. long				
U-8.....	1/16	45	5/8 to 3/4	Ran 87 in. Most of time the nose of tool was right on scale.
U-8.....	1/16 to 1/10	38	15/16	Went 127 in. Time 3 hrs. Speed increased to 65 f.p.m. after 105 in.
U-8.....	1/16	60	1 1/16	Ran 12 in.
Material cut: 12 in. forging				

The tools marked A, B, C and D are regular high-speed steel tools. Those marked U are uranium high-speed steel tools.

The manufacture of uranium high-speed steel is being taken up by a number of concerns. The tests of Table I were made under the direction of the Standard Chemical Company on a commercial scale at a number of the important shops in the Pittsburgh district.

Second National Exposition of Chemical Industries

The managers of the Second National Exposition of Chemical Industries which will be held at the Grand Central Palace, New York, during week of September 25-30, 1916, report that all space on the main floor has now been engaged, and that they have had to arrange for the second floor on which a great deal of space is already taken by exhibitors.

It is on this floor that the Government is expected to exhibit. Here also the "Made-in-America" meetings of the American Electrochemical Society will be held in the conference auditorium which the managers are erecting. The industrial conferences of the American Chemical Society, which will be presided over by its officers, in which heads of industries will participate, will also be held in this conference hall.

The American Paper and Pulp Association have their program in progress, and the managers report that they are organizing a section for the paper and pulp industry, which will cover considerable space on the second floor showing paper-making machinery, materials, products and by-products.

All motion pictures, covering every phase of industry, will be shown on this floor during the Exposition.

Several other societies have signified their intention

of supporting and exhibiting at the Exposition but have not as yet made known their programs.

With all these things, it is an assured fact that this exposition will transcend all the bounds of success of the former held last September.

Personal

Mr. Glenn L. Allen is now metallurgist for the Shattuck-Arizona Copper Company, Bisbee, Ariz.

Mr. M. H. Atwater is in charge of the erection of the electrolytic zinc plant for the Judge Mining & Smelting Company at Park City, Utah.

Messrs. C. C. Brayton and E. R. Richards have opened offices in the Hobart Building, San Francisco, as mining and metallurgical engineers.

Mr. H. Kenyon Burch, chief engineer for the Inspiration Copper Company, is taking a vacation in the East, following the completion of work on the design and construction of the company's concentrating plant in Arizona.

Mr. George A. Guess, professor of metallurgy in the University of Toronto, has been retained to start the copper smelter of the Vermont Copper Company at South Strafford, Vt.

Dr. Henry M. Howe, emeritus professor of metallurgy in Columbia University, has been appointed honorary vice-president of the Iron and Steel Institute of Great Britain.

Mr. E. C. Irwin has been appointed Cincinnati, Ohio, representative of the Asbestos Protected Metal Company, Pittsburgh.

Mr. Robert M. Keeney has resigned his position with the Snyder Electric Furnace Co. and is at his home in Chicago.

Mr. R. L. Lee has been appointed superintendent of the smelter of the Central Chili Copper Company at Panulcillo, Chile.

Mr. J. H. O'Brien of the American Blower Company, has been transferred from the Detroit office to the Chicago office, where he will give special attention to the air conditioning field in that territory.

Mr. H. A. Plusch, for the past seven years chief ceramic chemist for the Atlantic Terra Cotta Company, has resigned to take up the general field of consulting engineer in firebrick, refractory slab, terra cotta, faience, saggar, stoneware, sanitary ware, development of clay lands and new clay products. His offices will be at Perth Amboy, N. J.

Mr. W. H. Staver, formerly manager for the Liberty Bell Gold Mining Company, Telluride, Col., is investigating manganese deposits in the Southeast, and has opened an office in the Krise Building, Lynchburg, Va.

Messrs. Maurice W. Summerhayes and C. H. Poirier, respectively managers for the Porcupine Crown and Porcupine Vipond companies, have been selected to value the McIntyre, McIntyre Extension and Jupiter properties to determine the basis of a merger.

Dr. F. W. Traphagen, Golden, Col., has accepted the presidency of the Colorado Metal Mining & Reduction Company, and will devote his time to the company's metallurgical interests.

Mr. Charles E. van Barneveld is in New York on professional business and may be addressed care of the American Institute of Mining Engineers.

Mr. William H. Warren has been appointed manager of the works of the Brier Hill Steel Company at Youngstown, Ohio.

Mr. George J. Young, professor of metallurgy in the Colorado School of Mines, recently visited metallurgical plants in Nevada and California. He is spending the month of July on an outing in California.

Obituary

Sir William Ramsay, the eminent English chemist, died at his home, Beechcroft, at Haglemere, Bucks, in his sixty-fifth year, on July 23. He was born in Glasgow and educated in Glasgow Academy and University. He then took up teaching work and was subsequently associated with a number of universities, the last one being the University College of London, from which he retired as professor emeritus of chemistry in 1913. He was perhaps best known for his work on the gases of the atmosphere, including the discovery of argon in collaboration with Lord Rayleigh. He was the author of many valuable contributions to chemical literature, chiefly on the gases of the atmosphere, production of helium from radium, and general physical chemistry. He visited this country several times and was Lovering lecturer at John Hopkins University. He also delivered a number of lectures at other institutions. He was the recipient of the Nobel prize in 1904 and received a number of other prizes for his work. He was president of the Seventh International Congress of Applied Chemistry in London in 1909; was a past president of the Society of Chemical Industry and Chemical Society, and was a member of a large number of scientific societies.

Charles W. H. Kirchhoff, editor of the *Iron Age* from 1889 until 1910, and a past president of the American Institute of Mining Engineers, died at his summer home, at Asbury Park, on July 23, in his sixty-fourth year. He was born in San Francisco, Cal., and was graduated from the Royal School of Mines in Clausthal, Germany, in 1874. He returned to this country and was chemist of the Delaware Lead Refinery, Philadelphia, Pa., for three years. He joined the *Iron Age* in 1878 and remained until 1881, when he became managing editor of the *Engineering and Mining Journal*, returning to the *Iron Age* in 1884. In January, 1910, he was tendered a luncheon at the Engineers Club in New York by a number of his friends, in recognition of their admiration for him as an editor and a man. This was on the occasion of his retirement as editor of the *Iron Age*, with which he had been associated for over 30 years. He was a member of the American Iron and Steel Institute, The Iron and Steel Institute of Great Britain, The American Society of Mechanical Engineers, The Verein Deutscher Eisenhüttenleute and an honorary member of The Franklin Institute of Philadelphia.

Samuel Waterhouse, Jr., organic chemist, for some time past superintendent of the Frank L. May Chemical Company of Perth Amboy, N. J., died in the City Hospital of that city of aniline poisoning on July 8.

Industrial Notes

Nickel Refining—Premier Hearst, chairman of the Provincial Government Nickel Commission of Canada, is experimenting with an electrolytic nickel refining process, and considerable money will be spent on equipment.

The plant of the Virginia-Carolina Chemical Co., at Americus, Ga., was struck by lightning on July 10, and was subsequently destroyed by fire. The plant is said to be insured.

New Porcelain Ware Made in United States—The Guernsey Earthenware Co., Cambridge, Ohio, have issued Catalog No. 5 describing its new product, "Guernseyware," chemical laboratory porcelain. Tests made on

this porcelain have shown it to be the equal of the imported ware, and satisfaction is expressed by those who have used the products.

The German American Car Company announces a change in name to the General American Tank Car Corporation, and will continue its business under the same management and in the same manner as in the past, but with largely increased facilities.

The Block Chemical Laboratories of Chicago were incorporated under the laws of Illinois on June 16. The officers are: Dr. D. Julian Block, president; Prof. Robert M. Cole, vice-president, and Howel B. Keeler, secretary.

The Kansas Chemical Mfg. Co., at Hutchinson, Kan., is constructing a new \$30,000 hydrating plant and a \$20,000 lime plant of four kilns at Moline, Kan., where limestone quarries are located. The new plant will be ready for operation in about two months.

The Providence Engineering Society will occupy its new rooms at 29 Waterman Street, Providence, R. I., when it opens up for its fall and winter work next September. The whole second floor of the building has been taken over and will be remodeled and equipped in a modern and attractive manner. The society expects to pursue a very interesting and useful line of work for the coming year.

The Commercial Attache of the American Embassy at Paris, France, Mr. C. W. A. Veditz, is desirous of receiving catalogs, price lists and similar printed material from American concerns interested in the French and Spanish markets. The commercial office is in receipt of numerous inquiries for the names and addresses of American firms producing a variety of products and desires to have the catalogs on hand to show to inquirers.

The Hoskins Manufacturing Company, Detroit, Mich., announces a change in the address of its Boston office from 613 Unity Building, to 445 Tremont Building, 73 Tremont Street. The office will continue to be in charge of Mr. J. E. Hines.

Pulverized Coal in Open-Hearth Furnaces.—The Raymond Bros. Impact Pulverizer Co., Chicago, Ill., has recently received an order from the Carnegie Steel Co. for seventeen of its largest sized mills for pulverizing coal for use in open-hearth furnaces. Other orders have recently been received for experimental and complete installations.

New Building for Manufacture of Rubber Gloves.—The Lee Tire & Rubber Co. has just placed with John W. Ferguson Co. of New York, and Paterson, N. J., a contract for the erection of another building at its Conshohocken plant. To this building will be transferred that portion of the company's business which has to do with the manufacture of rubber gloves and similar rubber products. The building measures 80 ft. by 120 ft. in plan, and will for the present contain but two stories. The foundation and reinforced concrete columns on the first floor are designed, however, for several additional stories with the idea of probable expansion in view. A wooden roof will be placed over the second story. The walls of the building will be brick and the floors reinforced concrete. Steel sash will be used in the windows. H. M. Haven & Wm. W. Crosby of Boston drew up the plans and specifications.

The International Oxygen Company, with offices at 115 Broadway, New York, is installing a new plant at College Point, L. I., for the manufacture of oxygen and hydrogen gas. It is expected that the installation will be completed late in August or early in September, after which the company's increasing trade in Brooklyn

and environs, as well as in Manhattan, will be largely handled from this point. Heretofore this local business has been supplied from the company's Newark works, and the new location will mean larger and better facilities and more prompt service in the supply of gases in cylinders. The manufacture of gas-generating apparatus is the main business of the company, this feature of its work being concentrated at the Newark factory. The manufacture and distribution of gas in cylinders is a local and a secondary feature. The Newark and College Point plants supply Greater New York and the adjoining industrial section of New Jersey. The plant at Verona, Pa., has its outlet in the Pittsburgh district.

Digest of Electrochemical U. S. Patents

PRIOR TO 1903

Arranged according to subject-matter and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

Aqueous Bath, Cathodes Metalizing

29,144, July 17, 1860, Joseph Corduan of Brooklyn, N. Y.

Relates to electroplating the face of type with brass. To a saturated solution of blue vitriol add a caustic potash solution until no further precipitate forms. The precipitate is "black oxid of copper." It is washed well, and dried. The dried oxid is added to a cold solution of potassium cyanid until no more dissolves. To a similar solution of potassium cyanid, heated to boiling, is added oxid of zinc until no more dissolves. Equal volumes of the clear solutions are mixed and used as the electrolyte, while for a hard brass, an excess of the zinc solution is used; and for a soft brass, an excess of the copper solution is used. Brass vats are preferred to hold the electrolyte, and the vat may serve as anode, or a separate anode may be inserted in the solution. The type are assembled and held in a brass clamp, the faces being perfectly level, and the faces only immersed in the electrolyte.

63,512, April 2, 1867, Samuel Hallock of New York, N. Y.

Relates to an apparatus used in electrotyping, and consists of a frame to support the wax mold, and an auxiliary frame carrying a plurality of light spring contacts to make electric contact with the graphite on the face of the impressed mold. All submerged metal parts are protected by a coating of wax or rubber, except the contacting surfaces of the springs.

83,747, Nov. 3, 1868, Dennis C. Wilcox of Meriden, assignor to Meriden Britannia Company, of West Meriden, Conn.

Relates to the manufacture of double-walled ice pitchers, and similar vessels, and consists in electroplating the unprotected surfaces of the enameled or glazed metal at the edges where they are to be joined, and then soldering the joint at the electroplated parts.

90,892, June 1, 1869, Hiram Tucker of Newton, Mass. Relates to surfacing articles of cast metal which have raised and depressed portions. The depressed portions are filled with wax or other filling, and the raised portions, after suitably grinding and polishing, are electroplated with any desired metal. Or the raised surfaces may be electroplated first, and the depressed portions filled in with wax or the like, later.

94,453, Aug. 31, 1869, William T. Tibbals and Lyman B. Tibbals of Cobalt, Conn.

Relates to electroplating the joined and riveted edges

of such articles as cow-bells, the electroplated joint constituting an electro-soldered joint, and is effected at the same time that the bell is electroplated.

102,077, April 19, 1870, Joseph A. Adams of Brooklyn, N. Y.

Relates to electrotyping, and consists of a holder constructed to receive the black-leaded type-mold and frame, and make contact with the frame only. The holder consists of a hinged clamp, which may be screwed tight against the frame, and is provided with two points or lugs which engage corresponding holes or recesses in the frame. At the lower end of the clamp extending behind the frame is an adjustable clamp to hold the lower portion of the frame.

114,447, May 2, 1871, Silas P. Knight of Brooklyn, N. Y.

Relates to coating an electrotype mold with graphite, the graphite being first moistened with alcohol, and then mixed in the proportion of 1 lb. of graphite with 1 gal. of water. The mold filled with wax is first coated with water and graphite, the impression of the type made, then the mixture of water and graphite applied in fine streams from a "rose," and the excess of graphite finally washed and brushed off. Instead of graphite, bronze or similar powder may be used.

168,442, Oct. 5, 1875, William E. Worthen and Richard S. Gillespie of New York, N. Y.

Relates to electroplating such metallic objects made of iron and zinc with copper. The object is first coated with a mixture of red mercury oxid, alone or mixed with some mercury sulfid, and a waterproof vehicle, such as oil, to form an oxid of mercury paint, and this coating is then covered with a film of graphite. The article is then immersed in a solution of copper sulfate, and electrodeposited as usual. It is thought the mercury oxid and sulfid are reduced to metallic mercury, thereby forming a good connection through the paint to the metal beneath. If desired, copper rivets or wires may be secured in the metal object, extending through the paint and graphite coatings, and be united to the electrodeposit. Instead of depositing upon a metal object, the deposit may be made upon an article made from a mixture of ground coke and asphalt, thoroughly mixed while hot and molded into the desired shape. Such articles are first coated with graphite in the recessed parts, and electroplated, then the remainder coated with graphite, and electroplated. With large objects, such as a fountain, it is put into a tank and the electrolyte gradually increased in depth until it is entirely immersed, the anodes being raised with the electrolyte.

199,366, Jan. 22, 1878, Gustave Hubmann of New York, N. Y., assignor to Felix Marx of same place.

Relates to ornamenting marble and the like by electrodeposition. The marble is first cleaned, then coated with a light-sensitive emulsion of bichromate of potash and gelatine, then a suitable design made of varnished paper is secured to the emulsion, and the marble exposed to the light to render the exposed emulsion insoluble in water. The design is then removed, and the coating is then treated with alcohol to harden the emulsion not exposed to light. The marble is then placed in hot water to remove the non-exposed emulsion, after which the marble is washed and treated with acid to etch the uncovered portions. It is then washed with water and treated with benzine to remove the remaining coating, then the etched parts are varnished and coated with graphite, pieces of wire or rivets also being secured to the marble to anchor the deposit, and then immersed in an electrolyte to be copper-plated, after which the marble and deposit are polished and the metal engraved if desired.